A TEXTBOOK ON

INDUSTRIAL SAFETY

BY
Dr. S. KAMATCHI SANKARAN
Dr. T. PRABAKARAN

"Safety work is today recognized as an economic necessity. It is the study of the right way to do things. " - Robert W. Campbell

A TEXT BOOK ON INDUSTRIAL SAFETY

Authors **Dr.S.KAMATCHI SANKARAN, & Dr.T.PRABAKARAN**

First Edition: NOV 2022

Copyright© 2022 exclusive by the Author

This book or part thereof should not be reproduced in any form without the written permission of the author

Price: (Yet to be decided after getting ISBN)

ISBN: (Applied)

Published by and copies can be had from

MEENAKSHI SUNDARARAJAN ENGINEERING COLLEGE,
KODAMBAKKAM, CHENNAI – 600 024.

E-mail: kamsankarmith@gmail.com

Mobile: 9751339664, 9342201217

MEENAKSHI SUDARARAJAN ENGINEERING COLLEGE,

KODABAKKAM, CHENNAI-24.

DEPARTMENT OF MECHANICAL ENGINEERING

A TEXTBOOK ON
INDUSTRIAL SAFETY

WRITTEN BY

Dr. S.KAMATCHI SANKARAN,
Prof / Mechanical Engineering

Dr.T.PRABAKARAN
Asst.Prof/Mechanical Engineering

COMPOSED BY

S. GNANAPRAKASAM,
M KEERTHIVAASAN,
Final year Mechanical Engineering

Mechanical Engineering Department Vision of the Department

To develop creative mechanical engineers by providing quality education, research, and ethical values.

The mission of the Department

- To provide a conducive environment and facilities for academic activities and prepare students for diverse careers.
- To develop collaborative research with industries for excellence in research and consultancy practices
- To provide education in advanced technologies according to the changing needs of the society

Program Educational Objectives Statements

- **PEO1** To have a high level of technical competency combined with research and problem-solving skills to generate innovative solutions in Mechanical Engineering.
- **PEO2** To apply modern computational, analysis, simulation tools, and techniques to face the challenges in mechanical and allied engineering streams.
- **PEO3** To be able to communicate effectively and to practice their profession with high regard for social needs adhering to ethical practices.
- **PEO4** To update themselves in the areas and technologies that are relevant to their career and exhibit professionalism with team spirit.

Program Specific Outcomes

- **PSO1** Application of core subjects namely, Design, Manufacturing, Thermal Engineering, and Fluid Mechanics to Mechanical engineering Problems
- **PSO2** Familiarization of Modern Design and Analytical software such as AutoCAD, CREO, NASTRAN, ADAMS, CADEM, FluidSim, Lab view, and MATLAB for analyzing problems of Mechanical Engineering
- PSO3 Incorporate design and implementation of mechanical systems in societal and environmental issues

Program Outcomes

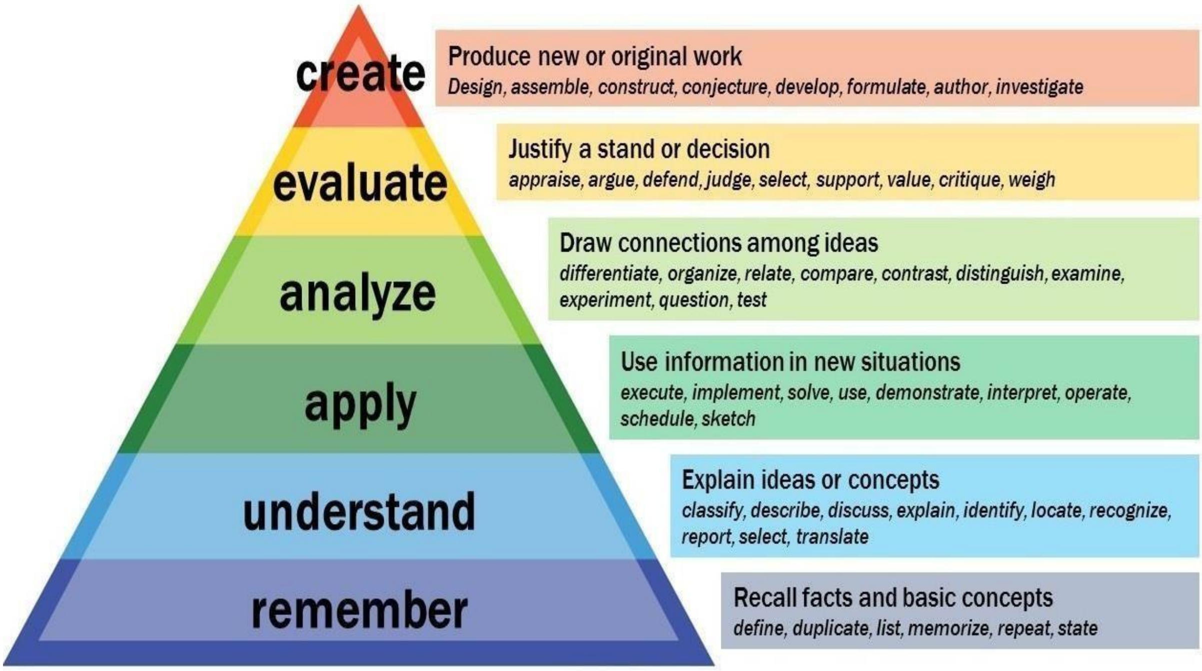
The graduates in Mechanical Engineering will:

- **PO1: Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- **PO2: Problem analysis**: Identity, formulate, review, research literature, and analyze complex engineering problems reaching

substantiated conclusions using the first principles of mathematics, natural sciences, and engineering sciences.

- **PO3: Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.
- **PO4: Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis, and interpretation of data, and synthesis of the information to provide valid conclusions.
- **PO5: Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- **PO6: The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- **PO7: Environment and sustainability**: Understand the impact of professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- **PO8 :Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- **PO9: Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and multidisciplinary settings.
- **PO10:Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- **PO11: Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- **PO12: Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

BLOOMS TAXONOMY



create
Produce new or original work
Design, assemble, construct, conjecture, develop, formulate, author, investigate

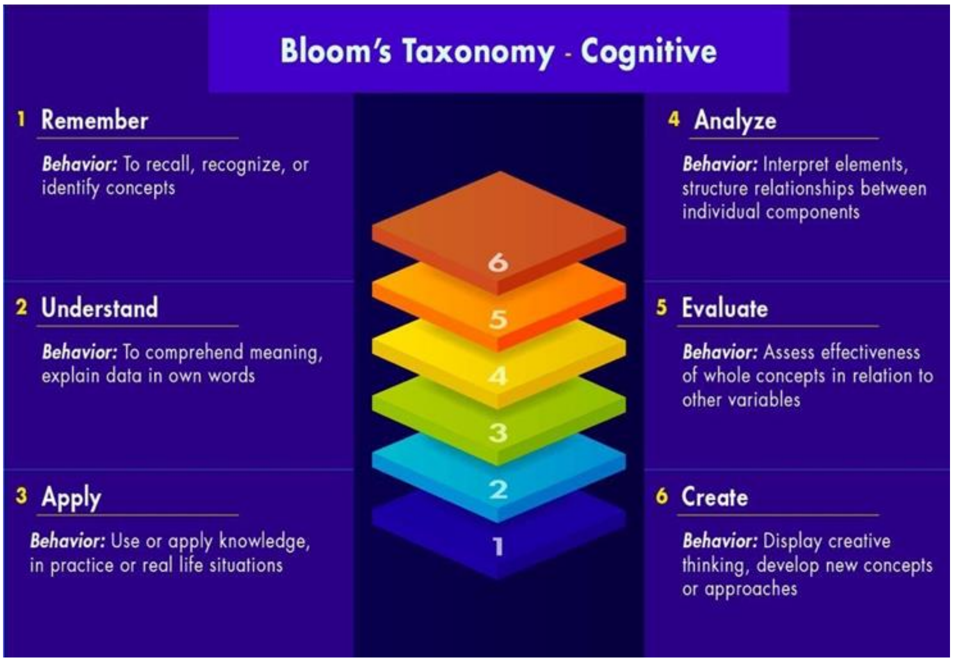
evaluate
Justify a stand or decision
appraise, argue, defend, judge, select, support, value, critique, weigh

analyze
Draw connections among ideas
differentiate, organize, relate, compare, contrast, distinguish, examine, experiment, question, test

apply
Use information in new situations
execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch

understand
Explain ideas or concepts
classify, describe, discuss, explain, identify, locate, recognize, report, select, translate

remember
Recall facts and basic concepts
define, duplicate, list, memorize, repeat, state



Bloom's Taxonomy - Cognitive

1 Remember
Behavior: To recall, recognize, or identify concepts

2 Understand
Behavior: To comprehend meaning, explain data in own words

3 Apply
Behavior: Use or apply knowledge, in practice or real life situations

4 Analyze
Behavior: Interpret elements, structure relationships between individual components

5 Evaluate
Behavior: Assess effectiveness of whole concepts in relation to other variables

6 Create
Behavior: Display creative thinking, develop new concepts or approaches

Course Outcomes

UNIT - 1	CO1: To ensure the desired plant availability at an optimum cost withinthe safety prescription.
UNIT - 2	CO2: Students can know about the objectives of maintenance.
UNIT - 3	CO3: To minimize the total cost of unavailability and resources.
UNIT - 4	CO4: Explain the repair methods of beds and slideways.
UNIT - 5	CO5: Discuss various condition monitoring techniques.

About the Author

Dr. S. Kamatchi Sankaran, M.E. (Thermal Engg) (Hons.), MBA (Production Management), Ph.D Mechanical Engineering (Material Science) is a professor in Mechanical Dept., at Meenakshi Sundararajan Engineering College, Chennai. He completed his Bachelor of Engineering in Mechanical Engineering in the year 2000 from **Annamalai University, Chidambaram**. In 2004, he completed an MBA in Production Management from **Madurai Kamaraj University**, **Madurai,** and, he completed his Master of Engineering (Hons.) in Thermal Engineering with a gold medal from **Anna University, Chennai**, in the year 2005. He then went on to complete his Ph.D. in Mechanical Engineering (Material Science-Powder Metallurgy) in the year 2020 from **Anna University, Chennai**.

He started his teaching carrier as a Lecturer and now serving as a Professor with 22 years of teaching experience. ***He published 8 papers in reputed International journals and published 14 papers in Internation Conferences and 6 papers in National Conferences.***

He also worked as an **Associate HoD** in the Mechanical Engineering Department at Sudharsan Engineering College in 2012. He also worked as **Vice Principal & HoD, Department of Mechanical Engineering**, M.A.R. College of Engineering and Technology. And M.I.E.T Engineering College., Trichy. His service also extended to working as a Chief Superintendent for Anna University semester examinations for more than Six semesters. He also worked as an **NBA and NAAC** coordinator.

For any queries/suggestions, contact: ***kamsankarmith@gmail.com, +91 97513 39664.***

About the Co-Author

Dr. T.Prabakaran, M.E. Ph.D. (Manufacturing department), is an Assistant professor in Mechanical Dept., at Meenakshi Sundararajan Engineering College, Chennai. He completed a Bachelor of Engineering in the department of Mechanical Engineering in the year 2005 from the **National Institute of Technology and** he completed a Master of Engineering in Manufacturing Engineering from **Anna University**. He then went on to complete his Ph.D. in Mechanical (Welding) in the year 2020 from **Anna University, Chennai**.

He started his professional carrier in Industries and got 10 years of industrial Experience. He started his teaching carrier as a Lecturer and now serving as a Professor after crossing 17 years of teaching experience. He published 7 papers in reputed International journals and published 10 papers in International Conferences and 5 papers in National Conferences.

He worked as an assistant professor at M.I.E.T Egg college. He also worked as an **HoD**in the Mechanical Engineering Department at M.A.M School of Engineering College in 2012. He also worked as **Vice Principal & HoD, Department of Mechanical Engineering**, and M.A.M. POLYTECHNIC COLEGE. He also worked as an NBA and NAAC coordinator for various colleges throughout his service.

For any queries/suggestions, contact: ***prabakaranmsec@gmail.com, +91 9342201217.***

ANNA UNIVERSITY SYLLABUS

OME-754 INDUSTRIAL SAFETY

Objective:

To impart knowledge on safety engineering fundamentals and safety management practices.

Syllabus:

UNIT I INTRODUCTION

Evolution of modern safety concepts – Fire prevention – Mechanical hazards – Boilers, Pressure vessels, Electrical Exposure.

UNIT II CHEMICAL HAZARDS

Chemical exposure – Toxic materials – Ionizing Radiation and Non-ionizing Radiation - Industrial Hygiene – Industrial Toxicology.

UNIT III ENVIRONMENTAL CONTROL

Industrial Health Hazards – Environmental Control – Industrial Noise - Noise measuring instruments, Control of Noise, Vibration, - Personal Protection.

UNIT IV HAZARD ANALYSIS

System Safety Analysis –Techniques – Fault Tree Analysis (FTA), Failure Modes and Effects Analysis (FMEA), HAZOP analysis and Risk Assessment

UNIT V SAFETY REGULATIONS

Explosions – Disaster management – catastrophe control, hazard control, Safety education, and training - Factories Act, Safety regulations Product safety – case studies.

Outcomes:

Students must be able to identify and prevent chemical, environmental mechanical, and fire hazards through analysis and apply proper safety techniques in safety engineering and management.

INDEX

TABLE OF CONTENTS

CHAPTER NO. **TITLE** **PAGE NO.**

1 INTRODUCTION 1

1.1 Definition of Industrial Safety 1

1.2 What is Industrial Safety? 1

1.2.1 Significance of Industrial Safety 1

1.2.2 Objectives of Industrial Safety 1

1.2.3 Ratios used to measure accidents 2

1.3 Safety on E^4 2

1.3.1 Safety Inspection Procedures 2

1.3.2 Safety Audit 2

1.3.3 Safety Survey 2

1.3.4 Evolution of modern safety concepts 3

1.3.5 Three important safety laws and rules 5

1.4 Fire Safety 5

1.4.1 There Are 4 Classes of Fire 6

1.4.2 Nine tips on how and when to use a fire Extinguisher 9

1.5 Common hazards associated with machinery 10

1.6 Non-Mechanical Machinery Hazards & Control Measures 16

1.7 Accidents in Pressure Vessels: Hazard Awareness 20

1.7.1 Causes of Failure 20

1.7.2 Hazard Awareness 21

1.7.3 Safety Approach 21

1.7.4 Precautionary Measures 22

1.8 Electrical Hazards 24

1.8.1 Examples of Electrical Hazards & Tips for Safety 25

2 CHEMICAL EXPOSURES 27

2.1 Types of Chemical Hazards 27

2.2 List of Toxic Materials 28

2.3 Ionizing and Non-Ionizing Radiation Study Guide 29

- 2.3.1 Ionizing Radiation 30
- 2.3.2 Types of Non-Ionizing Radiation and Their Clinical Effects 31
- 2.3.3 Types of Ionizing Radiation and Their Clinical Effects 33
  - 2.3.3.1 Electromagnetic Radiation 34
  - 2.3.3.2 Units of Ionizing Radiation Measurement 34
  - 2.3.3.3 Radiation Dose 34
  - 2.3.3.4 X radiation 35
  - 2.3.3.5 Gamma radiation 35
  - 2.3.3.6 Cosmic radiation 35

2.4 Radiation Protection 36

2.5 ALARA 37

2.6 Instructions for Radiation Detection and Measurement 37

- 2.6.1 Crystal Dosimeters 38
- 2.6.2 Dosimeters 38
- 2.6.3 Film badges 38
- 2.6.4 Ionization Chambers 39
- 2.6.5 Proportional Counters 39
- 2.6.6 The Scintillation Counter 40
- 2.6.7 Personnel-Monitoring Devices 41
- 2.6.8 Radiation Measurement 41

2.7 Management of Radiation Exposures 43

2.8 Industrial Hygiene 44

- 2.8.1 Key Components of Industrial Hygiene 45

2.9 Industrial Toxicology 47

- 2.9.1 Forms of toxicity 48
- 2.9.2 Important points for storage of toxic materials 50

3 **ENVIRONMENTAL CONTROL** 52
3.1 Industrial Health and Safety Hazards 52
3.2 Methodologies to Protect Workers 52
3.3 Seven Common workplace hazards 53
3.4 Administrative vs. Engineering controls 57
3.5 Office Safety: Designing a Safe and Functional Office 58
3.6 Environmental control 59
3.7 Industrial Noise Control 60
  3.7.1 Negative Effects of Noise Pollution 60
  3.7.2 Noise Measurement 63
3.8 Industrial Personal Protective Equipment (PPE) Equipment Overview 67
  3.8.1 Types of PPE 68
3.9 The 4 Basic Types 72

4 **SYSTEM SAFETY ANALYSIS** **77**
4.1 System Safety Analysis Techniques 77
  4.1.1 Fault Tree Analysis 77
  4.1.2 Drawing a Fault Tree Analysis 79
4.2 Failure Modes and Effect Analysis 83
  4.2.1 Introduction to Failure Mode and Effects Analysis (FMEA) 83
  4.2.2 The Steps for conducting FMEA 86
  4.2.3 FMEA Document Analysis 88
4.3 HAZOP: Hazard and Operability 88
  4.3.1 Objectives of HAZOP 89
  4.3.2 Types of HAZOP 89
  4.3.3 Purpose of HAZOP 89
  4.3.4 Importance of HAZOP for Multiple Industries 90
  4.3.5 HAZOP team leader Responsibilities 90

4.3.6 HAZOP team members 90
4.3.7 The Difference Between HAZOP, Risk Assessment, and HAZID 91
4.3.8 Study Process (Steps Involved) 92
4.4 Phases of Analysis 94

5 SAFETY REGULATIONS 96
5.1 Explosions 96
5.1.1 Additional requirements where explosive atmospheres can occur/Hazardous zone classification. 98
5.2 Disaster Management 99
5.2.1 Disaster Classification 99
5.2.2 Disaster Management Structure 100
5.2.3 Hurricane Preparedness Plan (Evacuation Plan) 100
5.3 Implementation Plan during Threats 102
5.3.1 Fire Prevention and Response Plan 102
5.4 Mitigation 104
5.5 Catastrophe Control 105
5.6 Hazard Control 106
5.7 Safety Education and Training 108

TWO MARKS QUESTION & ANSWERS UNIT-WISE 110

BIBLIOGRAPHY 136

UNIT – 1

INTRODUCTION

UNIT – 1

INTRODUCTION

1.1 Definition of industrial safety

- Safety is the state of being "safe", the condition of being protected against physical, social, spiritual, financial, or other types or consequences of failure, damage, error, accidents, harm, or any other event which could be considered non-desirable.

- This can take the form of being protected from the event or from exposure to something that causes health or economic losses.

1.2 What is industrial safety?

Industrial safety is primarily a management activity that is concerned with

- Reducing
- Controlling
- Eliminating hazards from the industries or industrial units.

1.2.1 Significance of Industrial Safety

- Industrial causes a great loss to both the Employer & Employee, that's it is having importance
- Cost of compensation
- Cost of medical-aid
- Cost of training a new worker
- Cost of the lost time
- Cost of investigation
- Cost of supervision & inspections
- Cost to the Govt. in terms of factory inspectors, & public health services

1.2.2 Objectives of Industrial safety

- To prevent accidents in the plant by reducing the hazard to a minimum.
- To eliminate accidents caused by a work stoppage and lost production.
- To achieve lower workmen's compensation, and insurance rates and reduce all other direct and indirect costs of accidents.
- To prevent loss of life, permanent disability, and the loss of income of workers by eliminating causes of accidents.
- To evaluate employee morale by promoting a safe workplace and good working conditions
- To educate all members of the organization in a continuous state of safety mindless and to make supervision competent and intensely safety minded
- Measurement & Records of Accidents

1.2.3 Two main ratios used to measure accidents are

- Accident Frequency Rate(AFC)
- Accident Severity Rate(ASR)
- AFC = No. of injuries * 10,00,000/ Total no. of man hours worked
- ASR = no. of man day lost * 10,00,000/Total no. of man hours worked
- Causes of Industrial Accidents
- Unsafe conditions
- Work schedules
- Psychological conditions
- Machinery & Equipment
- Unsafe Acts
- Miscellaneous Causes

1.3 Safety on E^4

- **Engineering:** i.e. safety at the design, and equipment installation stage.
- **Education:** i.e. education of employees in safe practices.
- **Enlistment:** i.e. it concerns the attitude of the employees and management towards the program and its purpose. This necessary arose the interest of employees in accident prevention and safety consciousness.
- **Encouragement:** i.e. to enforce adherence to safety rules and practices.

1.3.1 Safety Inspection Procedures

- Safety audit
- Safety survey
- Safety inspection

1.3.2 Safety audit

A safety audit subjects each area of a company's activity to a systematic critical examination to minimize loss.

1.3.3 Safety survey-

- A safety survey is a detailed examination in depth of a narrower field of activity.
- **Safety inspection-**
  - A routine scheduled inspection of a unit or department, which may be
  - carried out by someone (may be a safety representative) from within the unit, possibly
  - accompanied by the safety advisor.The inspection would check maintenance standards,

1.3.4 Evolution of modern safety concepts

- 15th century industrial work situations is very low
- 18th century working conditions started noticed. From that only law are created for labours
- 17th and 18th centuries they found houses of industry in which small children, even under five years of age, would be trained for apprenticeship with employers.
- From that it make to create a new law for labours.
- In the 19th century most of us affected by the works
- From that they give awakening to needs for control of hazards
- From that safety program are organized and then they follow
- At this time injurious effects were no longer dealt with simply as an economic problem. (19th century)
- A movement had started to determine the cause of injuries and effectuate their elimination. (19th century)
- From that a new movement formed.
- The rapid development of steam power and its application to manufacturing(the core of the Industrial Revolution) led to the growth of employment of children in city factories rather than in apprenticeship systems
- In 1784, a serious outbreak of fever in the cotton mills near Manchester appears to have incited the first governmental action for safety.
- In 1795, the Manchester Board of Health was formed. It advised legislation for the regulation of the hours and conditions of labour in the factories
- In 1802, the Health and Morals of Apprentices Act was passed, which in effect formed the first step toward regulated prevention of injury and protection of labour in English factories
- This law meet a failure because of training the labours. Because large number of children are employed in the factory.
- That children are worked in woolen mills without any primary education. They are worked for long time.
- The act did not apply to places employing fewer than 20 persons or 3 apprentices

- Inspector are appointed to enforce safety rules and regulation.
- The suffering and injury to children in the English factory system prompted legislative intervention in behalf of safety for the first time.
- Many English employers began to hire women to operate their new steam-driven machines
- In 1844, the first English law was passed regulating centuries observed in his medical practice that specific diseases seemed to work hours of adult women to 12 a day
- The first time, detailed provisions for health and safety began to make their appearance in the law
- Punitive (unsafe)compensation for preventable injuries caused by unguarded mining machinery was provided in 1842 by the Mines Act
- In 1843, the mine inspectors made their first report, but two years later the record notes that women still were employed underground
- the mines continued, and an organized governmental mine safety inspection program was begun in 1850
- This was followed by the act of 1855 which specified seven general safety needs for the inspectors to investigate
- A series of disastrous iron mine accidents and explosions resulted in an extension of the English law (Mines Act of 1860).
- The act of 1872 extended general safety rules, improved the method of formulating special safety rules, provided for certificated and competent management, and increased inspection
- The act of 1864 first embodied some of the results of inquiries of expert medical and sanitary observers by requiring ventilation to be applied for the removal of injurious gases, dust, and other atmospheric impurities originating from manufacturing processes
- the act of 1878 remained almost purely attempts to deal more adequately with those trades which had an injurious effect on safety and health
- 1883 provided that white lead factories should not be operated without a certificate of conformance with certain requirements
- 1889, certain procedures were specified for cotton cloth factories. Tests of compliance with regulations and records were required.

- 1891, the method of regulating unhealthy or dangerous occupations was extended by the application of special rules and requirements
- If the employee wished to secure redress from his employer, he could use the courts
- As a result of this point of view, coupled with an accelerating rate of work injuries, cases concerning employer's liability became increasingly frequent in the courts
- The injured employee, seeking indemnification in the courts to which he was entitled under the common law

1.3.5 THREE IMPORTANT SAFETY LAWS AND RULES

- The defence of contributory negligence provided that the employer was not responsible if the cause of accident was contributed to by the employee's own negligence. Although the employer may not have been absolved of liability, an apportionment of the burden of loss between the employer and employee could have been decided.
- The defence of assumption of risk allowed that an employer was not liable for injury caused by an unsafe work condition when the employee knew the facts and understood the risks of the employment. Some courts decided that when the employee accepted the job and continued it, despite the employer's failure to correct its hazards, the employer was relieved of any liability.
- The fellow servant rule provided that an employer was not liable to an employee who was injured through the negligence of a fellow employee

1.4 FIRE SAFETY

Each of these three elements must be present at the same time to have a fire. A fire will burn until one or more of the elements is removed.

Fuel

Any combustible material – solid, liquid or gas

Oxygen

The air we breathe is about 21% oxygen – fire needs only 16% oxygen

Heat

The energy necessary to increase the temperature of fuel to where sufficient vapors are given off for ignition to occur

1.4.1 THERE ARE 4 CLASSES OF FIRE:

FIRE TYPE Class A

Ordinary combustibles or fibrous material, such as wood, paper, cloth, rubber, and some plastics.

METHOD OF PREVENTION FOR CLASS "A" FIRE

- Keep storage and working areas free of trash.
- Place oily rags in covered containers

FIRE TYPE Class B

Flammable or combustible liquids such as gasoline, kerosene, paint, paint thinners and propane.

METHOD OF PREVENTION FOR CLASS "B" FIRE

- Don't refuel gasoline-powered equipment in a confined space, in the presence of an open flame, or while the equipment is hot.
- Keep flammable liquids stored in a tightly closed container and away from spark producing sources.
- Use flammable liquids only in well ventilated areas.

FIRE TYPE Class C

Energized electrical equipment, such as appliances, switches, panel boxes and power tools.

METHOD OF PREVENTION FOR CLASS "C" FIRE

- Never install a fuse rated higher than specified for the circuit.
- Investigate any appliance or electrical equipment that smells strange. Unusual odors can be the first sign of a potential fire.
- Utility lights should always have some type of wire guard over them.

FIRE TYPE Class D

Certain combustible metals, such as magnesium, titanium, potassium, and sodium.

METHOD OF PREVENTION FOR CLASS "D" FIRE

- Knowledge of the properties of the metals and using good judgment and common sense will assist you in controlling or avoiding potential fires/reactions.

BE PREPARED FOR A FIRE EMERGENCY

- Check the location of fire alarms and know how they work.
- Learn your building evacuation plan.
- Know where your two nearest exits are located. Learn how doors swing and where stairs lead.
- Make sure nothing blocks fire pulls, extinguishers and emergency exits.
- Learn the sound of your building fire alarm.
- Post emergency numbers (including security and first aid) near your telephone.
- Make sure you know what to do if the fire alarm sounds. Plan your escape. When you notice a fire
- Pull the nearest fire alarm “pull station” while exiting the floor.
- If there is no pull station, CALL EMERGENCY NUMBER IMMEDIATELY.
- Do not assume that anyone else has already called the fire department.
- Stay calm and be prepared to answer the operator’s questions regarding the emergency.

WHEN YOU HEAR THE FIRE ALARM:

- Leave at once, taking direction from the emergency warden.
- Do not delay yourself by gathering personal items. Your safety always comes first.
- Before you open any door, feel the door with the back of your hand. If the door is cold, slowly open it a crack.
- If there is no smoke in hallways or stairwells, follow your building’s evacuation plan. Get out quickly using designated fire exits.
- Close doors behind you, however do NOT lock the door. Locking the door hinders the fire department’s search and rescue efforts.
- The stairway will be your primary escape route. **Never, never use elevators under any circumstances**.
- Once in the stairway, proceed down to the first floor and out of the building. Never go up.

IF YOU ARE TRAPPED IN SMOKE OR HEAT

- Before you open any door, feel the door with the back of your hand. If the door is warm to the touch, DO NOT attempt to open the door.
- Stuff the cracks around doors with towels, rags, clothing or tape, and cover vents to keep out smoke.
- Stay low to the floor, and if possible, cover your mouth and nose with a damp cloth or dust mask to help you breathe.
- If there is a phone in the room where you are trapped, call the fire department to tell them exactly where you are located. Do this even if you see fire apparatus on the street below.
- Wait at a window and signal for help. Do not panic or jump!! WAIT!
- If possible, open the window at the top or bottom, but do not break it, you may need to close the window if smoke rushes in.
- Be patient. Rescuing all the occupants of a building can take several hours. After a fire emergency
- Once you are out of the building, STAY OUT! Do not go back inside for any reason.
- Report to your warden for roll call at your designated assembly point.
- Tell the fire department via your warden if you know of anyone trapped inside the building.
- Only re-enter if and when the fire department tells you it is safe to do so.

BEFORE you consider fighting a fire . .

- Call the fire department.
- Confirm that the fire is small and is not spreading.
- Confirm you have a safe path to an exit not threatened by the fire.
- You know what kind of extinguisher is required and the correct extinguisher is immediately at hand.
- The fire is spreading beyond the immediate area in which it started, or if it is already a large fire.
- The fire could block your escape route.

- You are unsure of the proper operation of the extinguisher.
- You doubt that the extinguisher you are holding is designed for the type of fire at hand or is large enough to fight the fire.

1.4.2 Nine Tips on How and When to Use a Fire Extinguisher

1. Most fires start small. Except for explosions, fires can usually be brought under control if they are attacked correctly with the right type and size of extinguisher within the first 2 minutes!

2. A fire extinguisher should be "listed and labeled" by an independent testing laboratory. The higher the rating number on an A or B extinguisher, the more fire it can put out. Be careful, high-rated units are often heavier models. Make sure you can hold and operate the model you are using.

3. Before attempting to fight a small fire, be sure everyone is out of the area. Ensure someone has called the fire department. If the fire starts to spread or threatens your escape path, get out immediately!

4. The operator must know how to use the extinguisher quickly without taking time to read directions during an emergency. Remember that the extinguishers need care and must be recharged after every use.

IF YOU FIGHT A FIRE, REMEMBER THE WORD

P A S S

PULL . . . AIM . . . SQUEEZE . . . SWEEP

5 **PULL**... the pin. Some extinguishers require releasing a lock latch, pressing a puncture lever or other motion.

6. **AIM**... low, pointing the extinguisher nozzle (or it's horn or hose) at the base of the fire.

7. **SQUEEZE**... the handle. This releases the extinguishing agent.

8. SWEEP... from side to side at the base of the fire until it appears to be out. Watch the fire area in case fire breaks out again, and repeat use of extinguisher if necessary.

9. Read and follow the directions on your extinguisher. If you have the slightest doubt about whether or not to fight a fire – DON’T! Get out and close the door behind you.

1.5 Common hazards associated with machinery:

1. Crushing Hazards

On construction sites, crushing hazards are often caused by excavators and other heavy machinery. If an employee is struck by a piece of machinery, it can result in serious injuries or even death. To prevent crushing hazards, employees should always be aware of their surroundings and stay clear of areas where heavy machinery is operating.

2. Shear Hazards

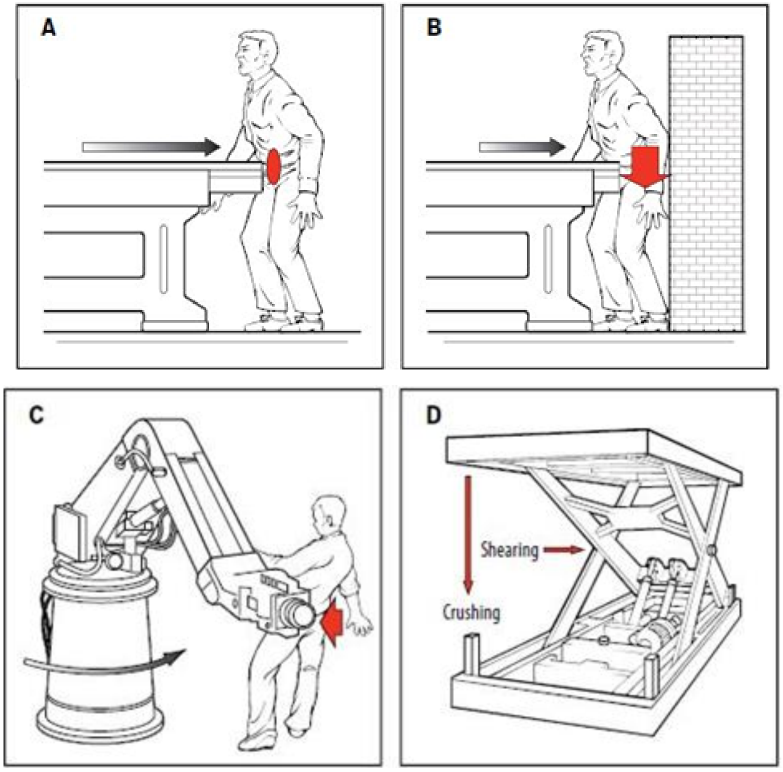


Fig. 1.1 Shear Hazard

Shear hazards are caused by moving parts that can cut or slice through skin and flesh. Shear hazards can occur when workers are using hand-operated tools, such as knives, or when they are operating machinery with moving parts, such as saws. To prevent shear hazards, employees should always use the proper safety equipment and procedures when working with hand-operated tools or machinery.

3. Cutting/Severing Hazards

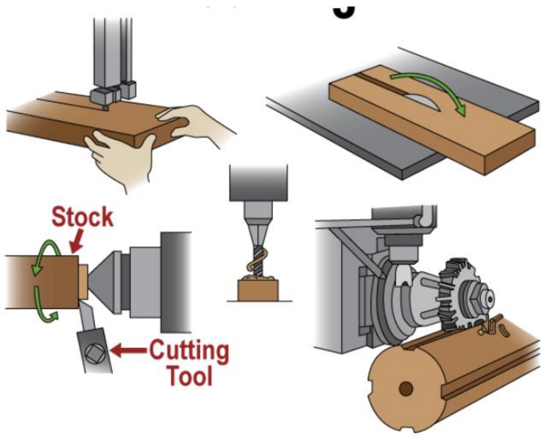


Fig. 1.2 Cutting

There are many types of cutting hazards, but the three most common are contact with a moving sharp-edged part, contact with a rotating part, and contact with a moving part.

The **first type** of cutting hazard is contact with a moving sharp-edged part. This can happen when you are using a machine with a blade, such as a bandsaw. If the blade is not properly guarded, your clothing or skin can come into contact with the blade and be cut.

The **second type** of cutting hazard is contact with a rotating part. This can happen when you are using a drill press or lathe. If the chuck or bit is not properly secured, your clothing or skin can come into contact with the rotating part and be cut.

The **third type** of cutting hazard is contact with a moving part. This can happen when you are using a power saw or drill. If the blade or bit is not properly secured, your clothing or skin can come into contact with the moving part and be cut.

To avoid these hazards, always make sure that the blades on your machines are properly guarded and that the chucks and bits on your drill presses and lathes are properly secured. If you are using a power saw or drill, make sure that the blade or bit is not worn or damaged. Also, always wear proper protective clothing, such as gloves, when using any type of machinery.

4. Drawing In Or Trapping Hazards

Fig. 1.3 Trapping Hazard

This hazard can occur when clothing or body parts become caught in moving parts of a machine. The result can be severe injuries or even death. To prevent this hazard, always make sure that you are wearing proper protective clothing, such as gloves and long sleeves when working with machinery. Also, keep your hands and feet away from moving parts and make sure that hair is tied back so that it cannot become caught in machinery.

5. Stabbing Or Puncture Hazards

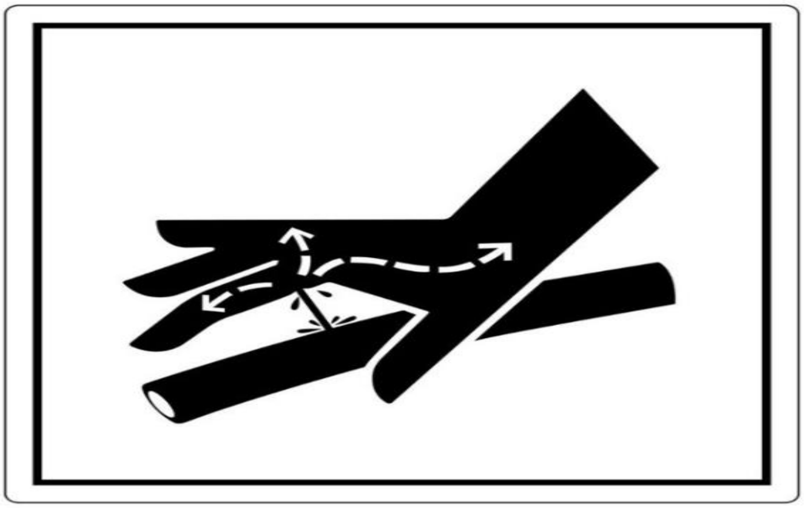


Fig. 1.4 Puncture Hazard

Stabbing or puncture hazards can occur when you are using a machine with a pointy or sharp edge, such as a drill press. If the bit is not properly secured, your clothing or skin can come into contact with the pointy or sharp edge and be punctured. To prevent this hazard, always make sure that the bit on your drill press is properly secured. Also, wear proper protective clothing, such as gloves, when using any type of machinery.

7. Friction Or Abrasion Hazards

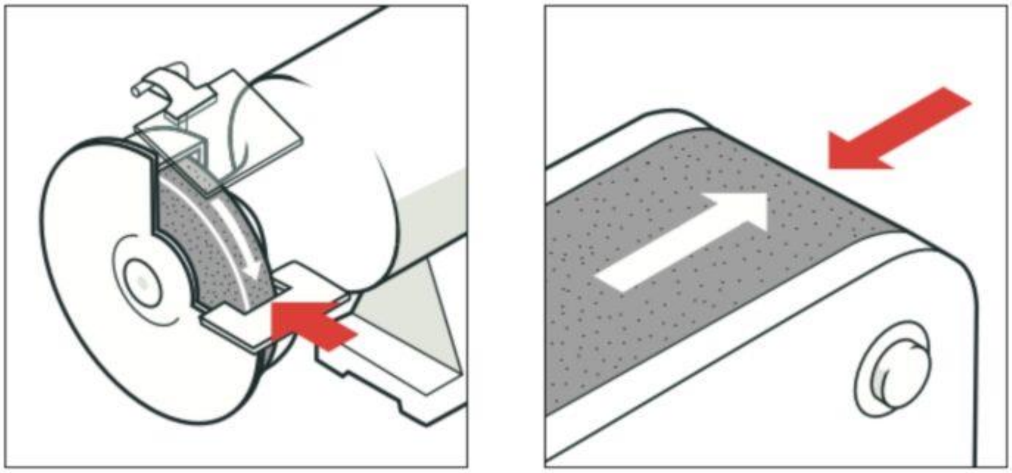


Fig. 1.5 Grinding Machine

There are several ways to protect yourself from these hazards:

- Wear appropriate Personal Protective Equipment (PPE), such as gloves, safety glasses, and ear protection.
- Be aware of your surroundings and stay clear of moving parts.
- Follow the manufacturer's instructions for operating the machinery safely.

8. Entanglement Hazards

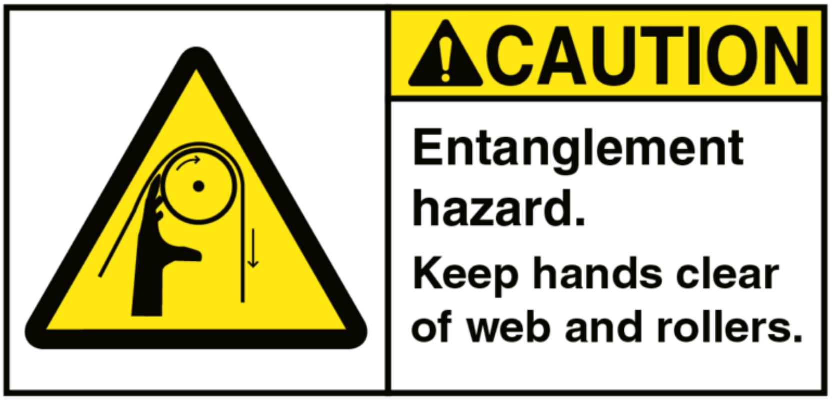

⚠CAUTION
Entanglement hazard.
Keep hands clear of web and rollers.

Fig. 1.6 Warning Sign for Entanglement Hazard

Entanglement hazards can occur when clothing or body parts become caught in moving parts of a machine. The result can be severe injuries or even death.

There are several ways to prevent this from happening:

- Keep your hair pulled back and away from rotating machine parts.
- Wear close-fitting clothes that won't get caught on anything.
- Be aware of your surroundings and what you're doing at all times.

If you see someone else caught in a machine, don't try to help them yourself. Turn off the machine and get help from someone who knows how to safely release them.

Entanglement is a very real hazard in any industry that uses machinery. By taking some simple precautions, you can prevent it from happening to you or anyone else.

9. Impact Hazards

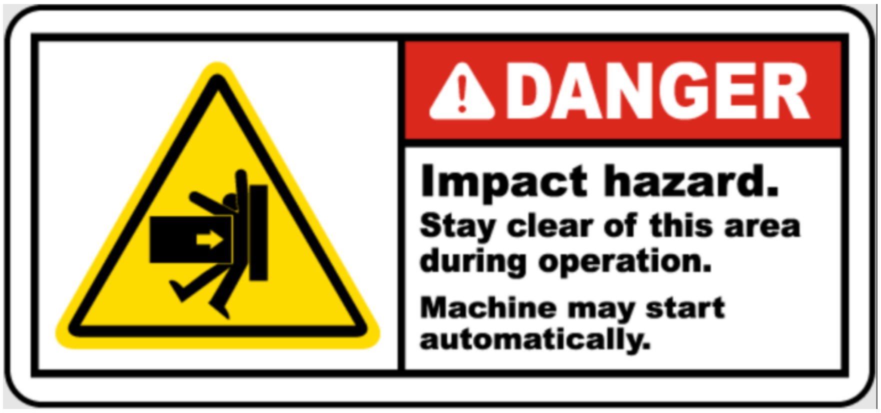

DANGER
Impact hazard.
Stay clear of this area during operation.
Machine may start automatically.

Fig. 1.7 Warning Sign for Impact Hazard

The most common type of impact hazard is when the body is struck by a powered part of a machine. This is similar to crushing, but there is no fixed structure to trap the person. The speed and weight of the object do the damage.

Impact hazards can also occur when two parts of a machine collide with each other. This can happen when two parts of a machine are not properly aligned, or when one part of a machine breaks and hits another part. Impact hazards can also occur when a person is hit by a flying object that has been thrown or ejected from a machine.

Impact hazards can be prevented by proper maintenance of machines, training of workers, and using safety devices. Impact hazards can also be minimized by the use of guards and barriers. When working with machines, it is important to be aware of the potential for impact hazards and to take precautions to avoid them.

10. High-Pressure Fluid Injection Hazards

The most common type of impact hazard is when the body is struck by a powered part of a machine. This is similar to crushing, but there is no fixed structure to trap the person. The speed and weight of the object do the damage.

Impact hazards can also occur when two parts of a machine collide with each other. This can happen when two parts of a machine are not properly aligned, or when one part of a machine breaks and hits another part. Impact hazards can also occur when a person is hit by a flying object that has been thrown or ejected from a machine.

Impact hazards can be prevented by proper maintenance of machines, training of workers, and using safety devices. Impact hazards can also be minimized by the use of guards and barriers. When working with machines, it is important to be aware of the potential for impact hazards and to take precautions to avoid them.

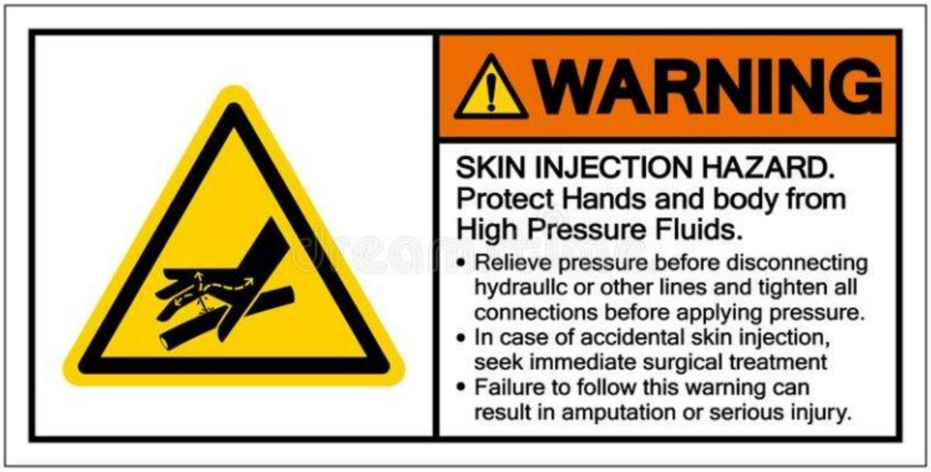

WARNING
SKIN INJECTION HAZARD.
Protect Hands and body from
High Pressure Fluids.
• Relieve pressure before disconnecting hydraullc or other lines and tighten all connections before applying pressure.
• In case of accidental skin injection, seek immediate surgical treatment
• Failure to follow this warning can result in amputation or serious injury.

Fig. 1.8 Warning Sign for Injection Hazard

High-pressure fluid injection is a hazard that can occur when fluids are forced into the body at high pressures. This can happen when a person is cleaning a machine with high-pressure water and the nozzle breaks or when a person is hit by a stream of high-pressure fluid from a ruptured hose. The high-pressure fluid injection can also occur when a person is welding and the arc flashes back, injecting molten metal into the body.

The high-pressure fluid injection can cause serious injuries or even death. Always use proper safety equipment when working with high-pressure fluids to prevent this hazard. Be sure to wear goggles or a face shield to protect your eyes, and wear gloves and protective clothing to protect your skin. If you are welding, be sure to wear a welding helmet to protect your face and neck.

1.6 Non-Mechanical Machinery Hazards & Control Measures

There are many types of hazards associated with non-mechanical machinery. Some of the most common are listed below.

1. Electricity

When working with non-mechanical machinery, it is important to be aware of the potential hazard of electricity. This can occur when the machine is not properly grounded or when there is a break in the electrical circuit. If you are using machinery that is not properly grounded, you could be at risk for electrocution. To avoid this hazard, make sure to follow the manufacturer's instructions for proper grounding.

If you are working with a machine with a break in the electrical circuit, you could be at risk for an electrical fire. To avoid this hazard, make sure to follow the manufacturer's instructions for proper circuit protection. Being aware of these hazards and taking proper precautions can help keep yourself safe when working with non-mechanical machinery.

2. Noise

Noise is a non-machinery hazard that can occur when using certain types of machinery. This can happen when the machine is not properly muffled or when there is a break in the sound-proofing material. Noise can also be a hazard when the machine is not properly shielded. Sometimes, noise can even be a hazard when the machine is turned off. If you are working with a machine that produces noise, it is important to take precautions to protect yourself from this hazard.

There are several ways that you can protect yourself from noise. First, you can make sure that the machine is properly muffled. This will help to reduce the amount of noise that is produced. Second, you can make sure that the machine is properly shielded. This will help to reduce the amount of noise that is produced. Finally, you can ensure the machine is turned off when not in use. This will help to reduce the amount of noise that is produced.

3. Vibration

Vibration is a hazard that can occur when using non-mechanical machinery. This can happen when the machine is not properly balanced or when there is a break in the vibration-dampening material. Vibration can also be a hazard when the machine is not properly shielded.

Exposure to vibration can cause a variety of health problems, including:

- Musculoskeletal disorders
- Blood vessel damage
- Nerve damage
- Inner ear damage
- Reduced blood flow to the hands and feet

If you are exposed to vibration on a regular basis, it is important to take steps to protect yourself. **Some ways to do this include:**

- Wearing vibration-dampening gloves
- Using a vibrating platform during breaks
- Taking regular breaks from exposure to vibration

If you think you may be suffering from a health problem caused by exposure to vibration, it is important to see a doctor as soon as possible. Early diagnosis and treatment can help to reduce the severity of the condition.

4. Hazardous Substances

A hazardous substance is a non-machinery hazard that can occur when using non-mechanical machinery. This can happen when the machine is not properly ventilated, or when there is a break in the containment system. Hazardous substances can also be a hazard when the machine is not properly labeled. Improper ventilation or a break in the containment system can release hazardous substances into the air, which can be breathed in by people working nearby. Hazardous substances can also come into contact with skin, eyes, or clothing and cause irritation, burns, or other injuries.

If you are working with hazardous substances, it is important to take precautions to protect yourself and others. Make sure the area is well ventilated, wear appropriate personal protective equipment, and follow all safety procedures. If you think you or someone else has been exposed to hazardous substances, seek medical attention immediately.

5. Ionising Radiation

Ionizing radiation is a hazard that can occur when using non-mechanical machinery. This can happen when the machine is not properly shielded, or during a break in the containment system. Ionizing radiation can also be a hazard when the machine is not properly labeled.

There are three main types of ionizing radiation: alpha, beta, and gamma. All three can be extremely harmful to human health if not properly controlled.

Alpha particles are the heaviest and most energetic type of radiation, making them the most dangerous. They can easily penetrate the skin and enter the body, where they can cause damage to DNA and other cells.

Beta particles are lighter and less energetic than alpha particles, but they can still penetrate the skin and cause damage to DNA.

Gamma rays are the lightest and least energetic type of ionizing radiation, but they can penetrate deep into the body, causing damage to DNA and other cells.

There are a number of ways to control the hazards posed by ionizing radiation. One is to use lead shielding, which can block alpha and beta particles. Another is to use distance, which can reduce the amount of radiation exposure. Finally, time can be used to reduce the amount of time spent in an area with high levels of ionizing radiation.

6. Non-Ionising Radiation

When using non-mechanical machinery, it is important to know the hazards of non-ionizing radiation. This type of radiation can occur when the machine is not properly shielded or when there is a break in the containment system. Non-ionizing radiation can also be hazardous when the machine is not properly labeled.

A few simple steps can be taken to help avoid these hazards. First, make sure that the machine is properly shielded. Second, check for breaks in the containment system. Finally, make sure that the machine is properly labeled. Taking these simple precautions can help ensure your safety when using non-mechanical machinery

7. Extreme Temperatures

One hazard that is often overlooked in non-mechanical machinery is extreme temperatures. Whether it is freezing cold or blistering hot, exposure to extreme temperatures can cause serious injuries or even death. In fact, extreme heat is one of the leading causes of occupational fatalities in the United States. OSHA reports that approximately 40 workers die from heat exposure every year.

There are a number of ways to protect yourself from extreme temperatures when working with non-mechanical machinery. If possible, avoid working in extreme conditions altogether. If you must work in hot or cold conditions, take frequent breaks to cool down or warm up as needed. Wear appropriate clothing for the conditions, and be sure to drink plenty of fluids to stay hydrated. If you start to feel dizzy, lightheaded, or nauseous, stop working and seek medical attention immediately.

Taking precautions and being aware of the dangers can help keep yourself safe while working with non-mechanical machinery.

8. Ergonomics

Ergonomics is a non-machinery hazard that can affect workers who perform tasks that require them to use their bodies in awkward or repetitive ways. Poor ergonomic conditions can lead to injuries of the muscles, tendons, and nerves, as well as back pain and other musculoskeletal disorders. To prevent these injuries, ergonomic principles should be followed when performing tasks.

There are many ways to apply ergonomic principles to task performance. First, workers should be aware of their own body mechanics and how they can use them to their advantage. Second, workers should be aware of the hazards associated with their task and take steps to avoid them. Finally, workers should use proper lifting techniques and posture when performing tasks that require them to lift or move heavy objects. By following these ergonomic principles, workers can help prevent musculoskeletal injuries and other health problems.

9. Machine Maintenance

Another hazard that is often overlooked in non-mechanical machinery is poor maintenance. When machines are not properly maintained, they can become unsafe to use. This can lead to a number of hazards, including electrical shocks, fires, and explosions. In order to prevent these hazards, it is important to perform regular maintenance on all machines.

There are a few simple steps that can be taken to ensure proper machine maintenance. First, make sure to read the owner's manual and follow all instructions. Second, perform regular visual inspections of all machines. Finally, keep all machines clean and free of dust and debris. By taking these simple steps, you can help ensure your safety when using non-mechanical machinery.

10. Slips, Trips, And Falls

Another hazard that is often overlooked in non-mechanical machinery is the potential for slips, trips, and falls. These hazards can occur when workers are not paying attention to their surroundings or when they are not using proper safety equipment. Slips, trips, and falls can lead to several injuries, including cuts, bruises, broken bones, and head injuries. To prevent these hazards, it is important to be aware of your surroundings and to use proper safety equipment when working with non-mechanical machinery.

11. Fire And Explosion

Another hazard that is often overlooked in non-mechanical machinery is the potential for fire and explosion. This hazard can occur when flammable materials are present near heat sources or when electrical equipment is not properly maintained. Fire and explosion can lead to several injuries, including burns, smoke inhalation, and death. To prevent this hazard, it is important to be aware of fire hazards and to take steps to prevent them.

A few simple steps can be taken to prevent fire and explosion. First, always keep flammable materials away from heat sources. Second, perform regular maintenance on all electrical equipment. Finally, have a fire extinguisher readily available in case of an emergency. By taking these simple steps, you can help prevent fire and explosion.

12. Chemical Hazards

Another hazard that is often overlooked in non-mechanical machinery is the potential for chemical hazards. This hazard can occur when chemicals are not properly stored or used. Chemical hazards can lead to several injuries, including chemical burns, respiratory problems, and death. To prevent this hazard, it is important to be aware of the dangers of chemicals and to take steps to avoid them.

A few simple steps can be taken to prevent chemical hazards. First, always store chemicals in proper containers and in a safe location. Second, be aware of the dangers of chemicals and follow all safety instructions. Finally, wear proper protective clothing when working with chemicals. By taking these simple steps, you can help prevent chemical hazards.

1.7 Accidents in Pressure Vessels: Hazard Awareness

Pressure vessels store substances under pressure higher than atmospheric conditions and are found all over the place. They are used in homes and hospitals for hot water storage, in many different factories and plants, and in mining and oil refineries.

Pressure vessels store large amounts of energy; the higher the operating pressure and the bigger the vessel, the more the energy released in the event of a rupture and consequently the higher the extent of damage or disaster or the danger it poses, hence there should be no complacency about the risks. Unfortunately, pressure vessels accidents happen much more than they should. This paper presents different accounts of pressure vessels accidents, hazard

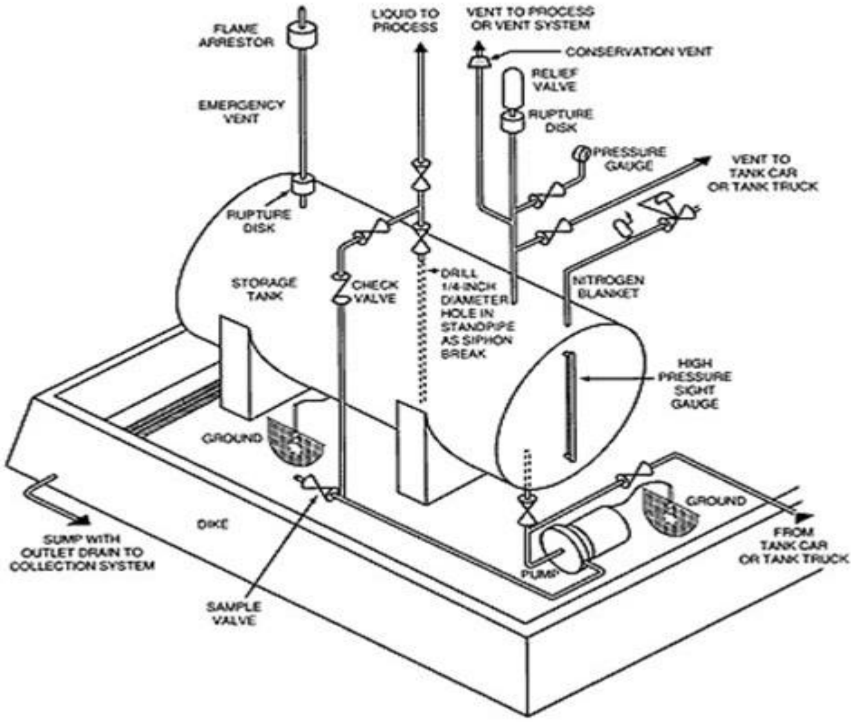

FLAME ARRESTOR
LIQUID TO PROCESS
VENT TO PROCESS OR VENT SYSTEM
CONSERVATION VENT
RELIEF VALVE
RUPTURE DISK
EMERGENCY VENT
PRESSURE GAUGE
VENT TO TANK CAR OR TANK TRUCK
RUPTURE DISK
STORAGE TANK
CHECK VALVE
DRILL 1/4-INCH DIAMETER HOLE IN STANDPIPE AS SIPHON BREAK
NITROGEN BLANKET
HIGH PRESSURE SIGHT GAUGE
GROUND
GROUND
DIKE
SUMP WITH OUTLET DRAIN TO COLLECTION SYSTEM
PUMP
FROM TANK CAR OR TANK TRUCK
SAMPLE VALVE

Fig. 1.9 Aqueous Methylamines Storage

1.7.1 CAUSES OF FAILURE

The main causes of failure of a pressure vessel are as follows:

- Faulty Design
- Operator error or poor maintenance
- Operation above max allowable working pressures
- Change of service condition
- Over temperature
- Safety valve
- Improper installation
- Corrosion
- Cracking
- Welding problems

- Erosion
- Fatigue
- Stress
- Improper selection of materials or defects
- Low –water condition
- Improper repair of leakage
- Burner failure
- Improper installation
- Fabrication error
- Over pressurisation
- Failure to inspect frequently enough
- Erosion
- Creep
- Embrittlement
- Unsafe modifications or alteration
- Unknown or under investigation

1.7.2 HAZARD AWARENESS

The potential danger associated with pressure vessels failure if not properly designed, constructed, operated, inspected, tested, or repaired are:

- Blast Effects
- Fragmentation damage
- Suffocation
- Poisoning
- Fire Explosion
- Chemical burns
- Thermal burns
- Loss of lives and property
- Permanent injuries or disabilities on affected people
- Loss of earning/income

1.7.3 SAFETY APPROACH

There are standards and codes laid down by approved regulatory bodies for the design, construction, welding, testing, marking, operation, inspection, and repair of anypressure vessel, which provides fundamental safeguards and good safety practices. The standards and codes vary from country to country, the commonly used codes are:

- ASME Boilers and Pressure Vessel Codes
- API Standards
- PD5500
- British Standards
- European Codes and Standards
- Other International Codes

1.7.4 PRECAUTIONARY MEASURES

The catastrophic disasters caused by pressure vessel accidents could be totally prevented by;

- Designing, fabricating and constructing pressure vessels to comply with applicable codes and standards, and where no pressure vessel law exists, to internationally recognised pressure vessel safety codes.
- Operating the vessel at pressure below the maximum allowable working pressure with proper pressure setting of relief devices, to handle design pressures and temperatures.
- Periodically testing and inspecting the vessel as well as the relief devices in order to detect corrosion or erosion of the vessel that can cause holes, leaks, cracks, general thinning of the vessel walls or any other defects. Safety relief valves must be taken off during safety inspection to verify whether their settings are correct.
- Keeping records of inspection reports and monitoring potential problem, so that the vessel may be taken out of service before it becomes dangerous. Also, having all information displayed prominently.
- Ensuring that alterations or repairs of vessels are only done by competent and authorised persons and the repair must meet the accepted industry quality standards for pressure vessel repair.
- Providing safety training for employees on job hazard and anticipated conditions that could jeopardize their safety or the safety of others.
- Periodically provide training for operators on vessels operating procedures to avoid over pressurizing, as well as providing them with adequate and suitable instructions for vessel safe operations.

Problem areas

- ✓ Sinus passages
- ✓ Middle ear
- ✓ Lungs
- ✓ Nitrogen absorption
- ✓ Decompression sickness
- ✓ Rapid decrease in pressure

Partial pressure hazards

- ✓ Hypoxia - reduced available oxygen
- ✓ Hyperoxia - too much oxygen
- ✓ Nitrogen narcosis - higher than normal nitrogen pressure

Boilers & pressure vessels

- ✓ **Safety hazards**
- ✓ Design, construction, installation
- ✓ Poor training of operators
- ✓ Human error
- ✓ Mechanical failure

- ✓ Failure of safety devices
- ✓ Improper inspections
- ✓ Improper application of equipment
- ✓ Insufficient preventive maintenance

Boilers & pressure vessels

- ✓ **Safety hazards**
- ✓ Failure of safety devices
- ✓ Improper inspections
- ✓ Improper application of equipment
- ✓ Insufficient preventive maintenance
- ✓ **Same issues for unfired pressure vessels**

Hazards - high pressure systems

- ✓ Leaks
- ✓ Pulsation
- ✓ Vibration
- ✓ Release of high pressure gases
- ✓ Whiplash from broken lines

Pressure danger to humans

- ✓ Anoxia - no oxygen available
- ✓ Hypoxia - reduced oxygen
- ✓ Altitude sickness
- ✓ Hyperoxia - increased concentration of oxygen

Pressure danger to humans

- ✓ Trapped gas effects in the body
- ✓ Evolved gas effects - body not able to dissipate absorbed gases fast enough
- ✓ Dysbarism - formation of gas bubbles in blood and tissue
- ✓ Creeps, chokes

Measurement of pressure hazards

- ✓ Sounds - don’t use fingers
- ✓ Cloth streamers - soap solutions
- ✓ Scents
- ✓ Leak detectors
- ✓ Corrosion

Causes of gas leaks

- ✓ Contamination by dirt of mechanical joints
- ✓ Overpressurization
- ✓ Excessive temperature
- ✓ Operator errors

Reducing pressure hazards

- ✓ Proper storage
- ✓ Training & testing of personnel
- ✓ Periodic inspections
- ✓ Proper operating conditions
- ✓ Relieve pressure from system
- ✓ Label pressure system - inspection, pressure, flow direction

Reducing pressure hazards

- ✓ Use appropriate materials
- ✓ Pressure relief devices
- ✓ Keep hoses short
- ✓ Avoid impacts
- ✓ Secure cylinders
- ✓ Examine labels

1.8 Electrical Hazards

The major hazards associated with electricity are electrical shock, fire and arc flash. Electrical shock occurs when the body becomes part of the electric circuit, either when an individual comes in contact with both wires of an electrical circuit, one wire of an energized circuit and the ground, or a metallic part that has become energized by contact with an electrical conductor.

The severity and effects of an electrical shock depend on a number of factors, such as the pathway through the body, the amount of current, the length of time of the exposure, and whether the skin is wet or dry. Water is a great conductor of electricity, allowing current to flow more easily in wet conditions and through wet skin.

The effect of the shock may range from a slight tingle to severe burns to cardiac arrest. The chart below shows the general relationship between the degree of injury and amount of current for a 60-cycle hand-to-foot path of one second's duration of shock. While reading this chart, keep in mind that most electrical circuits can provide, under normal conditions, up to 20,000 milliamperes of current flow.

What is Electrical Safety?

Electrical safety is a general practice of workers who are exposed to handling and maintaining electrically powered equipment. It is a set of guidelines they follow to mitigate electrical hazards and prevent its dangerous effects in case of an incident. Unable to adhere to electrical safety can lead to accidents, near misses, or even fatalities.

1.8.1 Examples of Electrical Hazards & Tips for Safety

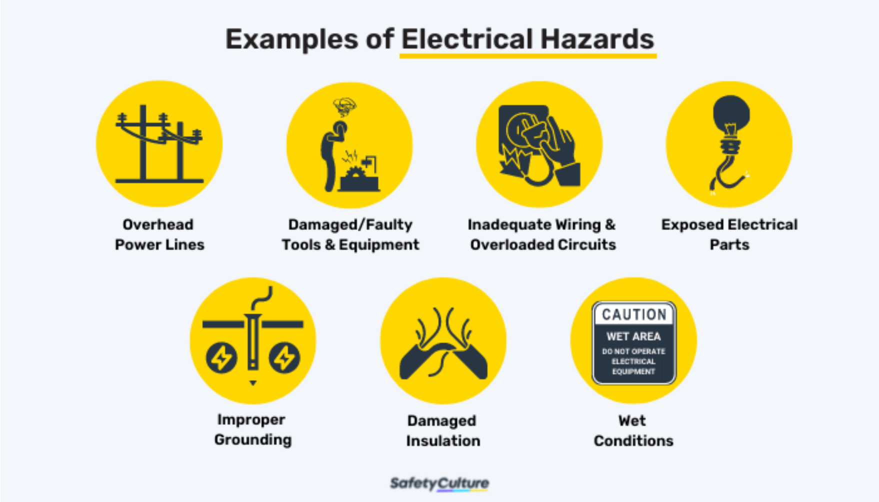

Examples of Electrical Hazards
Overhead Power Lines
Damaged/Faulty Tools & Equipment
Inadequate Wiring & Overloaded Circuits
Exposed Electrical Parts
Improper Grounding
Damaged Insulation
CAUTION
WET AREA
DO NOT OPERATE ELECTRICAL EQUIPMENT
Wet Conditions
SafetyCulture

Fig. 1.10 Electrical Hazards

1. **Overhead Power Lines**

Overhead powered and energized electrical lines have high voltages which can cause major burns and electrocution to workers. Remember to maintain a minimum distance of 10 feet from overhead power lines and nearby equipment. Conduct site surveys to ensure that nothing is stored under overhead power lines. Also, safety barriers and signs must be installed to warn nearby non-electrical workers of the hazards present in the area.

2. **Damaged Tools and Equipment**

Exposure to damaged electrical tools and equipment can be very dangerous. Do not fix anything unless you are qualified to do so. Thoroughly check for cracks, cuts, or abrasions on cables, wires, and cords. In case of any defects, have them repaired or replaced. Lock Out Tag Out (LOTO) procedures should be performed at all times before commencing electrical maintenance and repairs. LOTO procedures are there to protect all workers on a worksite.

3. **Inadequate Wiring and Overloaded Circuits**

Using wires of inappropriate size for the current can cause overheating and fires to occur. Use the correct wire suitable for the operation and the electrical load to work on. Use the correct extension cord designed for heavy-duty use. Also, do not overload an outlet and use proper circuit breakers. Perform regular fire risk assessments to identify areas at risk of bad wiring and circuits.

4. Exposed Electrical Parts

Examples of exposed electrical parts include temporary lighting, open power distribution units, and detached insulation parts on electrical cords. These hazards can cause potential shocks and burns. Secure these items with proper guarding mechanisms and always check for any exposed parts to be repaired immediately.

5. Improper Grounding

The most common OSHA electrical violation is the improper grounding of equipment. Proper grounding can eliminate unwanted voltage and reduce the risk of electrocution. Never remove the metallic ground pin as it is responsible for returning unwanted voltage to the ground.

6. Damaged Insulation

Defective or inadequate insulation is a hazard. Be aware of damaged insulation and report it immediately. Turn off all power sources before replacing damaged insulation and never attempt to cover them with electrical tape.

7. Wet Conditions

Never operate electrical equipment in wet locations. Water greatly increases the risk of electrocution especially if the equipment has damaged insulation. Have a qualified electrician inspect electrical equipment that has gotten wet before energizing it.

UNIT – 2

CHEMICAL HAZARDS

UNIT – 2

CHEMICAL EXPOSURES

Chemical Hazards in Industry is a literature updating service providing information on safety and health hazards surrounding chemicals encountered in chemical and related industries, including topics such as health and safety, chemical and biological hazards, plant safety, legislation, protective equipment and storage.

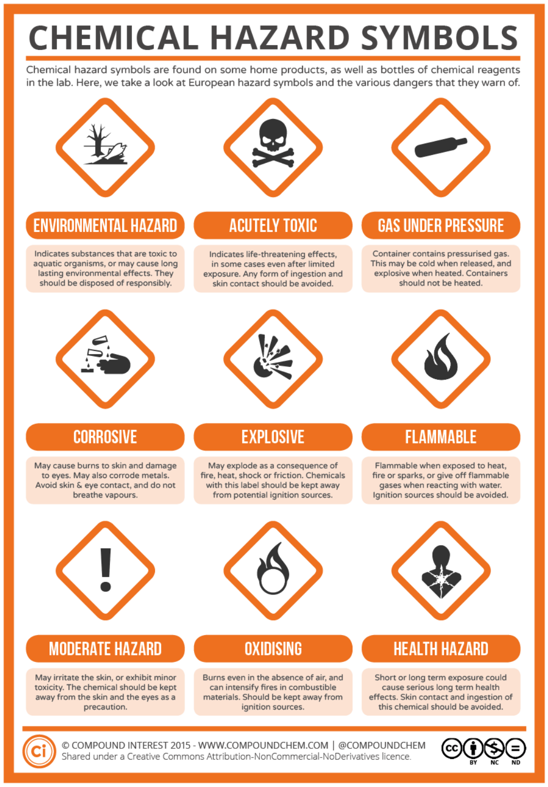
A **chemical hazard** is a (non-biological) substance that has the potential to cause harm to life or health. Chemicals are widely used in the home and in many other places. Exposure to chemicals can cause acute or long-term detrimental health effects. There are many types of hazardous chemicals, including neurotoxins, immune agents, dermatologic agents, carcinogens, reproductive toxins, systemic toxins, asthmagens, pneumoconiotic agents, and sensitizers.[2] In the workplace, exposure to chemical hazards is a type of occupational hazard. The use of protective personal equipment (PPE) may substantially reduce the risk of damage from contact with hazardous materials. Long-term exposure to chemical hazards such as silica dust, engine exhausts, tobacco smoke, and lead (among others) have been shown to increase risk of heart disease, stroke, and high blood pressure

2.1 TYPES OF CHEMICAL HAZARDS

Hazard	**Example**
Flammable and Combustible Liquids	**Diesel**
Compressed Gases	**Propane**
Explosives	**TNT**
Organic Peroxides	**Methyl ethyl ketone peroxide; used in the manufacturing of polyester**
Reactives	**Benzoyl peroxide; used as a bleaching agent**
Oxidizers	**Potassium permanganate; used as an industrial disinfectant and sterilizer**
Pyrophorics	**White phosphorus**
Carcinogens	**Benzene; feed-stock for many petrochemical processes**
Reproductive toxins	**Lead**, Dioxins
Irritants	**Hydrochloric acid; used in food manufacturing and ore processing**
Corrosives	**Sulfuric acid; used to manufacture chemicals**
Sensitizers	**Latex; used to manufacture gloves**
Hepatotoxins	**Trichlorethylene; used widely in industry**
Nephrotoxins	**Naproxen (an NSAID)**
Radioactive materials	**Uranium** salts, Plutonium

2.2 LIST OF TOXIC MATERIALS

Lead	Acetone
Mercury	Bis(chloromethyl) ether
Asbestos	Chemical substance
Arsenic	Hexavalent chromium
Formaldehyde	Tetrachloroethylene
Acrolein	Bis(2-ethylhexyl) phthalate
Ammonia	Sulphur dioxide
Chlorine	Carbon tetrachloride
Acrylonitrile	Bromine
Cadmium	Nickel tetracarbonyl
Pesticides	Naphthalene
Biphenyl	Dichloroethane
Ethylene oxide	Dichlorobenzidine
Phosgene	Arsenic trioxide
Phthalates	Polychlorinated biphenyl
Acetaldehyde	Acetone cyanohydrin
Hydrogen cyanide	Bromine pentafluoride
Chromium	Chlorine trifluoride



CHEMICAL HAZARD SYMBOLS

Chemical hazard symbols are found on some home products, as well as bottles of chemical reagents in the lab. Here, we take a look at European hazard symbols and the various dangers that they warn of.

ENVIRONMENTAL HAZARD

Indicates substances that are toxic to aquatic organisms, or may cause long lasting environmental effects. They should be disposed of responsibly.

ACUTELY TOXIC

Indicates life-threatening effects, in some cases even after limited exposure. Any form of ingestion and skin contact should be avoided.

GAS UNDER PRESSURE

Container contains pressurised gas. This may be cold when released, and explosive when heated. Containers should not be heated.

CORROSIVE

May cause burns to skin and damage to eyes. May also corrode metals. Avoid skin & eye contact, and do not breathe vapours.

EXPLOSIVE

May explode as a consequence of fire, heat, shock or friction. Chemicals with this label should be kept away from potential ignition sources.

FLAMMABLE

Flammable when exposed to heat, fire or sparks, or give off flammable gases when reacting with water. Ignition sources should be avoided.

MODERATE HAZARD

May irritate the skin, or exhibit minor toxicity. The chemical should be kept away from the skin and the eyes as a precaution.

OXIDISING

Burns even in the absence of air, and can intensify fires in combustible materials. Should be kept away from ignition sources.

HEALTH HAZARD

Short or long term exposure could cause serious long term health effects. Skin contact and ingestion of this chemical should be avoided.

© COMPOUND INTEREST 2015 - WWW.COMPOUNDCHEM.COM | @COMPOUNDCHEM
Shared under a Creative Commons Attribution-NonCommercial-NoDerivatives licence.

Fig. 2.1. Chemical Hazard Symbols

2.3 Ionizing and Non-Ionizing Radiation Study Guide

Radiation- Energy emitted from a body or source that is transmitted through an intervening medium or space and absorbed by another body. Transmission is in the form of waves but wave/particle duality under quantum physics.

Radiation is classified as being either **non-ionizing** or **ionizing**. Non-ionizing radiation is longer wavelength/lower frequency lower energy. While ionizing radiation is short wavelength/high frequencyhigher energy.

- **Ionizing radiation** is a form of energy that acts by removing electrons from atoms and molecules of materials that include air, water, and living tissue. Ionizing radiation can travel unseen and pass through these materials. It is on the right side of the electromagnetic spectrum in the figure below.
- **Non-ionizing radiation** exists all around us from many sources. It is to the left of ionizing radiation on the electromagnetic spectrum in the figure below.

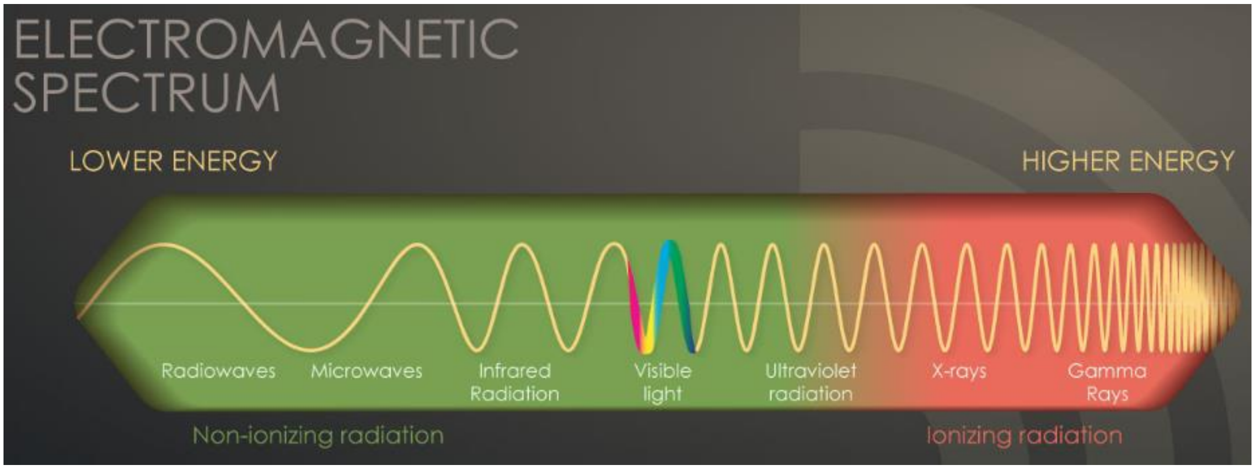


Fig. 2.2 Electromagnetic Spectrum

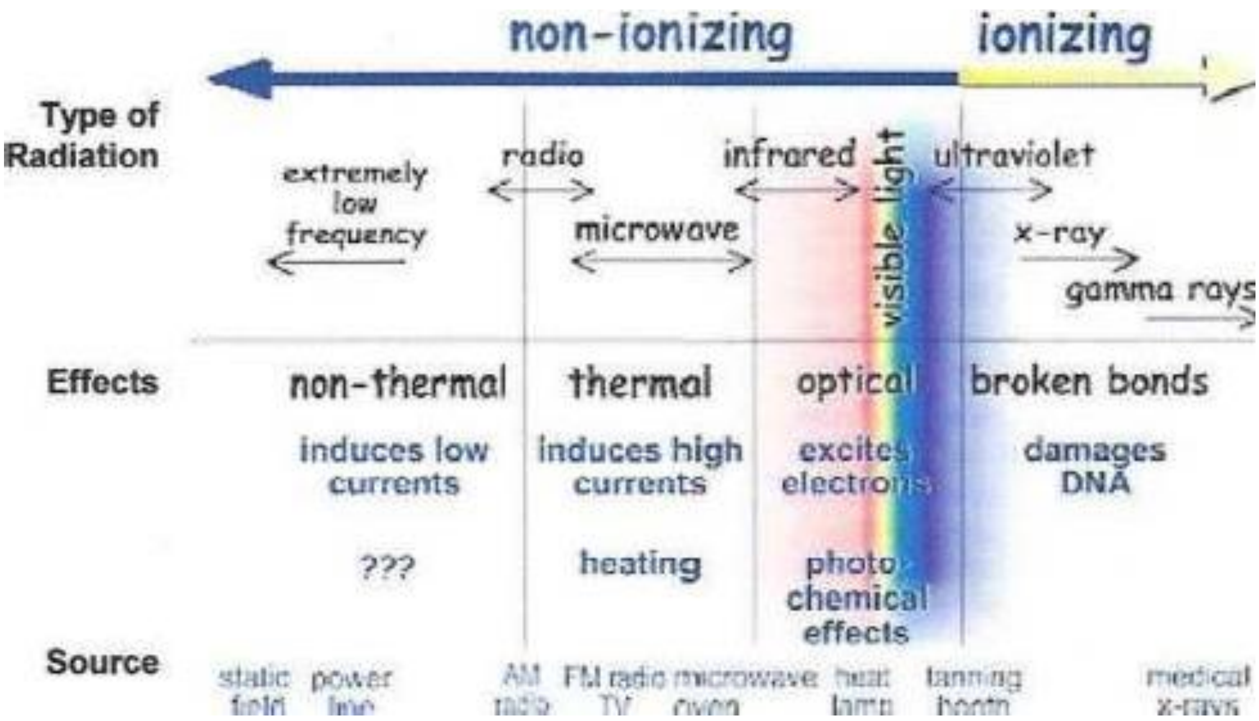


Fig. 2.3 Types of Radiation

Examples include:

- Radiofrequency (RF) radiation used in many broadcast and communications applications
- Microwaves used in the home kitchen
- Infrared radiation used in heat lamps

The dividing line between ionizing and non-ionizing radiation occurs in the ultraviolet part of the electromagnetic spectrum [shown in the illustration of the electromagnetic spectrum above]. Radiation in the ultraviolet band and at lower energies (to the left of ultraviolet) is called non-ionizing radiation, while at the higher energies to the right of the ultraviolet band is called ionizing radiation.

2.3.1 Ionizing Radiation

Non-ionizing radiation is the term given to radiation that has insufficient energy to cause ionization.

These kinds of radiations contradict with ionizing radiation like x-rays, gamma rays, and alpha particles, which are on the other end of the spectrum and are unstable and reactive.

Following are the types of non-ionizing radiation:

1. Ultraviolet radiation
2. Visible light
3. Infrared
4. Microwave
5. Radio waves
6. Very Low Frequency (VLF)
7. Extremely Low Frequency (ELF)
8. Thermal radiation
9. Black-body radiation

2.3.2 Types of Non-Ionizing Radiation and Their Clinical Effects-

Referring again to the chart above we can see that Non-Ionizing radiation comes in the forms of:

1. ELF (extremely low frequency)
2. Radio Frequencies
3. Microwave Frequencies
4. Lasers
5. Infrared
6. Visible Spectrum
7. Ultraviolet

This list is in order of lowest to highest frequency.

Clinical Effects-

1. ELF

Power plant or line workers Inconclusive evidence of leukemia link

2. Radiofrequency and Microwave Frequency Exposures-

Occupational Exposures-

Radar and communications equipment, industrial and commercial ovens

Other Exposures

Cell Phones

There is a great deal of controversy regarding potential cancer risks, particularly with cell phone use. We know that exposure to radio and microwave frequency sources cancause burns and clinically this is what you are most likely to see.

3. LASER (Light Amplification by Stimulated Emission of Radiation)

Beams of coherent light with single wavelength and frequency May be in the IR, Visible or UV spectrum Eye is most sensitive to injury from LASER

Four classes by risk of injury:

1. No damage
2. Low chance for damage due to blink
3. A)Cause injury with direct exposure B)Cause injury even when reflected
4. Requires controls to prevent injury

4. Infrared

- Penetrates superficial layers of the skin, causes thermal injury, potential for damage to the cornea, iris, lens of the eye
- Welding, glassmaking, heating and dehydrating processes

5. Visible Spectrum

- 400 to 750nm wavelengths
- ROYGBIV (Red, Orange, Yellow, Green, Blue, Indigo, Violet) Possibility of retinal injury from 400-500 nm blue frequencies

6. Ultraviolet Radiation

- 200nm to 400 nm Bridge between Non-Ionizing and Ionizing Radiation Three regions UV-A 315nm- 400nm UV-B 280nm-315nm UV-C ‹280nm
- A and B bands produce biologic effects on the skin and the eyes. Photokeratitis, conjunctivitis, sunburn, photosensitization reactions, skin cancers Majority of exposures are to outdoor workers, other exposures include welders, people who work in drying and curing industries and laboratory, kitchen or medical industries exposed to germicidal ultraviolet

2.3.3 Types of Ionizing Radiation and Their Clinical Effects-

Ionizing radiation is emitted from radioactive atomic structures as high energy electromagneticwaves (gamma and x-rays) or as actual particles (alpha, beta, neutrons)

1. Gamma Rays
2. X-Rays
3. Alpha Particles
4. Beta Particles
5. Neutrons

When the atom is in a stable or unexcited state, the electrons move in orbits at a certain distance from the nucleus.

When the atom absorbs energy in its orbital area, the orbital distance of the electrons is increased, and the atom is said to be excited or in an unstable state

The atom absorbs or emits energy in a certain amount, called a quantum (or a photon), during such a transition.

In each atom several transitions are possible within a fixed energy-level scheme.

- Radiation is emitted from either the atom's unstable nucleus or its unstable orbital area and is divide into two general types:

    1 Particulate radiation

    2 Electromagnetic radiation

    3 The motion of small particles which have mass and (in most cases) electric charge and which transfer energy from one point to another.

    4 These tiny portions of matter behave somewhat like a billiard ball.

    5 Particles that change their velocity also change in energy (by changing energies, particles will also change in mass).

    6 They receive energy when any force accelerates them.

    7 They release energy when any force or atomic constituent impedes their motion.

    8 Particles, by transferring energy to atoms, cause ionization, light, and heat

    9 Particulate radiation, on the other hand, always moves with a speed less than light.

    10 The energy of a photon depends upon the frequency of the electromagnetic radiation associated with it.

2.3.3.1 Electromagnetic radiation

- Electromagnetic radiation consists of varying electric and magnetic fields, operating at right angles to each other
- Electromagnetic radiation is said to consist of small bundles of energy called photons or quanta
- The energy of a photon depends upon the frequency of the electromagnetic radiation associated

2.3.3.2 Units of Ionizing Radiation Measurement

- The most widely accepted units are the roentgen, rep, rad, and rem
- The roentgen is a measure of ionization in air due to X or gamma radiation.
- The rep is a measure of radiation in human tissue.
- The rad measures the energy absorbed by radiation in any material.
- The rem relates the different radiation's effectiveness in producing biological damage to the quantity of radiation

2.3.3.3 Radiation Dose

- A dose of 1 roentgen due to X or gamma radiation.
- A dose of 1 rad due to X, gamma, or beta radiation.
- A dose of 0.1 rad due to neutrons or high- energy protons.
- A dose of 0.05 rad due to particles heavier than protons and with sufficient energy to reach the lens of the eye.

For example, 10,000 roentgens may be applied safely to a small part of the body in radiation therapy; but only 500 roentgens, one twentieth of this, if applied to the entire body, would be lethal in about 50 percent of the cases

The alpha particle is a stable, rapidly moving unit of two protons and two neutrons propelled from a disintegrating nucleus. Its composition is the same as the nucleus of a helium atom. As the fast-moving alpha particle slows down in its passage through matter, it acquires two electrons and becomes a helium atom.

Alpha particles with an energy level of 6 million electron volts will travel approximately only 2 inches in air. In solid materials the range is reduced to several thousandths of an inch. If the skin's protective layer were to be penetrated by an alpha particle, the energy of the particle would have to be about 7.5 million electron volts.

www.rejinpaul.com

For this reason, alpha radiation is considered to present a hazard 20 times greater than that of beta or gamma radiation.

- The neutron has a mass about the same as the proton but has no electrical charge.
    - Therefore it does not ionize directly but causes ionization by secondary means.
    - Ions formed are the result of other types of radiations emitted during interactions between neutrons and atomic nuclei
    - Slow neutrons react with many body elements, hydrogen being the most common
    - The emission of high-energy gamma radiation is the result of an interaction with a hydrogen nucleus
- Other slow neutron interactions result in the
- production of ion-producing beta particles.
- Fast neutrons, in the body, may produce protons which have a relatively high specific ionization.
- Experiments indicate that fast neutrons are four to five times more lethal to tissue than is X radiation.

2.3.3.4 X radiation

The emission occurring when high-speed electrons are directed at a metal target and slowed down by the attraction of positive nuclei in the atoms of the target

2.3.3.5 Gamma radiation

It is typically electromagnetic, having very short wavelengths and very high frequencies.

This radiation normally occurs when a radioactive nucleus progresses toward a less excited state.

Example, radioactive radium passing through many transitional intermediary stages to finally reach stable lead.

2.3.3.6 Cosmic radiation

- Hazard to the human body primarily during flights high in space
- Originate high in the atmosphere above the earth, when high energy, heavy nuclei
- These heavy nuclei are termed primary cosmic radiation
- Few primary particles reach the earth's surface, since the atmosphere acts like a protective shield

The primary particle either loses its energy by ionization and excitation, orbit strikes atmospheric nuclei and promotes secondary cosmic radiation.

Biological Effects and Assumptions

- The body generally responds to cell damage in the same way, regardless of the cause, and so the symptoms of radiation injury generally approximate those of a variety of other illnesses

2.4 RADIATION PROTECTION

- Industrial research irradiated tools or parts to measure the wear of cutting tools, pistons, wire-drawing dies.
- Radiology to replace X rays in checking steel castings, welded joints.
- Gauging to measure and control the thickness of steel, paint, paper, rubber, and other processed products.
- Tracers to follow fluid flow in process lines, transfer of printing ink.
- Ionizers to eliminate static electricity in textile and paper lines.
- Polymerization to speed or initiate chemical reactions by catalytic action.
- Radiation low-intensity light sources for exit signs, storage bins, traffic lane markers.

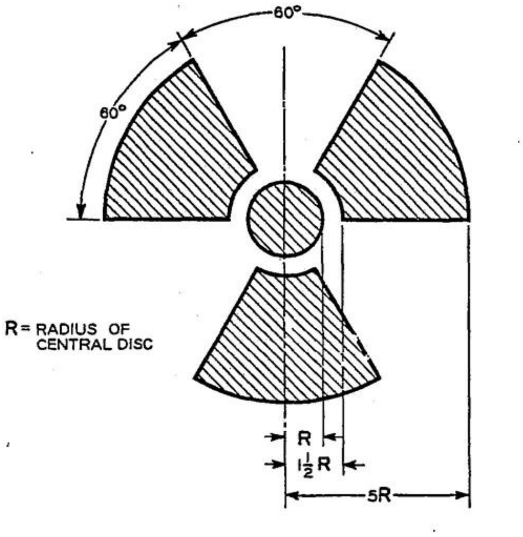


Fig. 2.4 The ANSI Standard Radiation Symbol

2.5 ALARA

- The "as low as reasonably achievable" (ALARA) concept is intended to reduce occupational exposures as far below the specified limits as is reasonably achievable by means of good radiation protection planning and practice. The principle of ALARA is an extension of an original recommendation by the National Committee on Radiation Protection (NCRP),
- It is generally considered that two fundamental requirements, for maintaining occupational radiation exposures as low as they can be achieved within reason, are management commitment and vigilance by the radiation safety officer and staff.
- For example, investigations conducted at the Lawrence Livermore National Laboratory indicate that all cancers related to bomb fallout at Hiroshima were produced by gamma rays, since no significant neutron radiation was found to be present.

2.6 INSTRUMENTS FOR RADIATION DETECTION AND MEASUREMENT

- The selection of survey instruments for radiation detection and measurement is made from a group of many kinds of survey devices, each designed to monitor a particular type and energy level of radiation.
- Safety specialists should be aware, however, that alpha particles are the most difficult type of radiation to detect because their range is short (less than 5 inches in air) and they are easily absorbed.
- Alpha monitoring devices usually are proportional counters, ionization chambers, and scintillation detectors
- These devices are equipped with very thin windows so that the alpha particles are not absorbed before they are detected.
- The measurement of beta and gamma radiation normally is accomplished by the use of devices employing an ionization chamber or Geiger- Miiller tube.

- In cases where beta and alpha radiations are mixed,
- the proportional counter is useful for distinguishing between the two types and various beta energy levels
- The radiation-measuring devices employed for health protection are designed for one of three measurement purposes
  - Determination of contamination,
  - Determination of dosage, and
  - Determination of dosage rate.

For example, devices used for detecting gamma radiation may not be sensitive to beta.
Devices for measuring radiation for the protection of health include the following:

- Crystal Dosimeters
- Dosimeters

- Film badges
- Ionization Chambers
- The Geiger-Muller Counter (Geiger Counter)
- Proportional Counters
- The Scintillation Counter
- Personnel-Monitoring Devices

2.6.1 Crystal Dosimeters

- These are detection instruments utilizing the property of certain crystals (i.e., silver chloride, potassium bromide, thallium bromide) to absorb a part of the radiation energy to which they are exposed, in an amount proportional to the dosage.
- The dosage is evaluated by placing the crystal in an electrical circuit and exposing it to a controlled light source, that has the effect of releasing the stored energy in the form of a measurable, brief flow of electrical current.

2.6.2 Dosimeters

- This term includes several types of dose- measuring devices.
- It may refer to ionization chambers (described below), which are of a pocket size and equipped with a meter which measures the changes in electrical potential caused by the ionization effect.
- The meter is calibrated to give the measurement directly in roentgens.

2.6.3 Film badges

- The use of film badges employs the effect that radiant energy has on exposed photographic- type film emulsions, permitting a quantitative estimate of the radiation energy to which they have been exposed by comparing the exposed film with a calibration film.

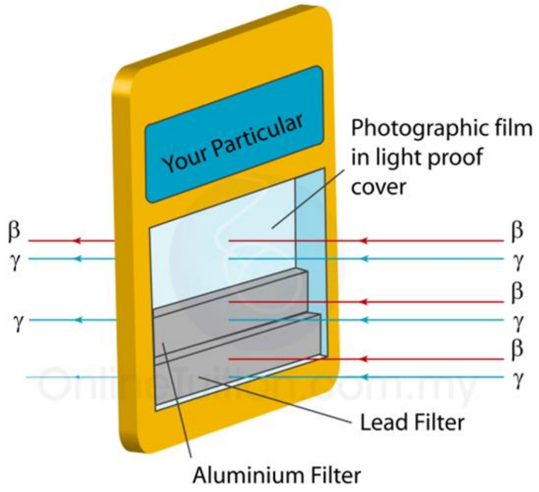


Fig.2.5 Film Badge Dosimeter

- For example, if the hands are the most frequently exposed part, a finger-ring type badge should be used.
- The records of dosimeter readings and film badge measurements should be kept carefully for medical and insurance purposes.

2.6.4 Ionization Chambers

- The ionization chamber is essentially two electrically conducting plates—one connected to the positive (+) pole of a battery, the other connected to the negative (-) pole
- Thus one plate (the anode) is charged positively, while the other (the cathode) is charged negatively
- A quantitative change in the charge on each plate, resulting in the measurable flow of an electric current.
- The many radiation-measuring instruments of the ionization chamber type behave somewhat differently, according to the magnitude of this voltage.

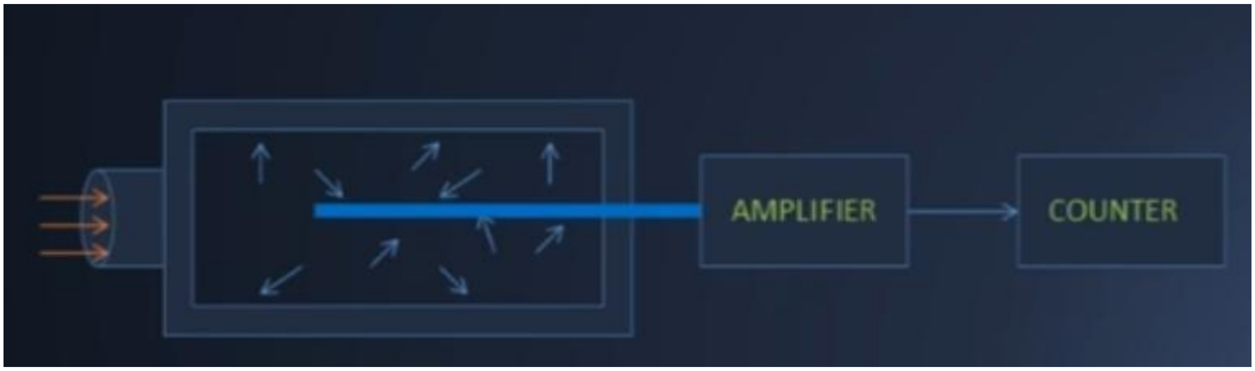


Fig.2.6 Ionization Chamber

2.6.5 Proportional Counters

- The proportional counter is basically like the Geiger counter, but it has the characteristic of producing a pulse which is proportional to the number of ions produced in the gas by the original ionizing radiation.
- Methane 10% and organ 90% gas are filled
- Tungsten filament in the centre
- These counters have the ability to distinguish between radiations having different energies and are useful, therefore, in detecting and measuring alpha rays.
- They may be designed, in fact, to count alpha particles when both beta and gamma radiation are also present in the chamber, and are considered more satisfactory detectors of neutrons than the Geiger counters

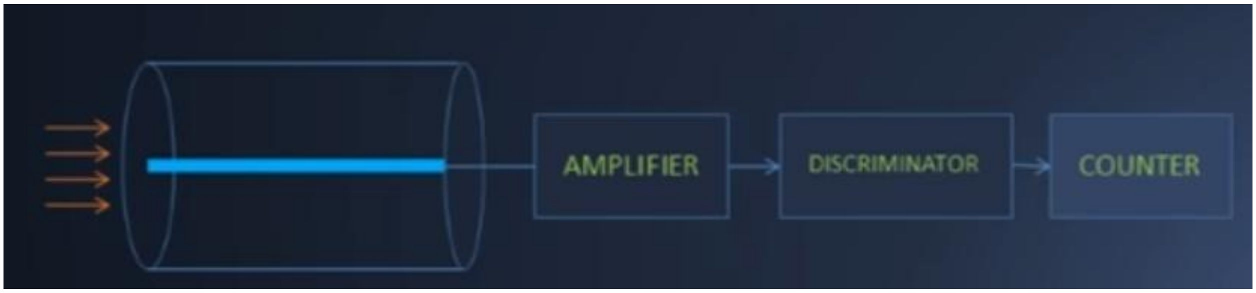


Fig.2.7 Proportional Counters

2.6.6 The Scintillation Counter

- This counter utilizes the property certain materials have of emitting scintillations (flashes of light) when struck by radiant energy.
- Television picture tubes are examples of this phenomonen.
- In the scintillation counter a device called a photomultiplier tube is employed.
- It made from single crystal.(it transparent light)
- Crystal power should be high
- Cesium iodide gamma ray
- Zinc sulphide heavy particles
- Organic phosphors are used for detection of gamma ray
- Xenon heavy particles
- Thallium Activated sodium iodide (its spoil due to moisture)

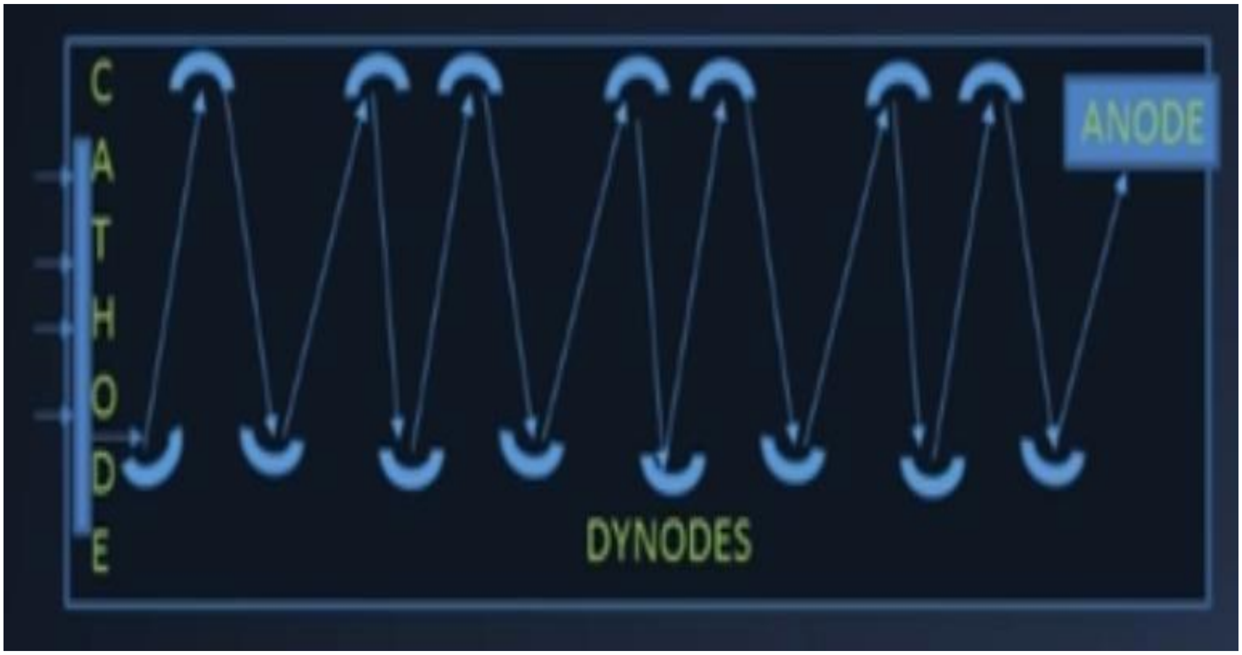


Fig.2.8 The Scintillation Counter

2.6.7 Personnel-Monitoring Devices

- In as much as a person exposed to an excess dose of radiation can be injured without realizing it, various monitoring devices are used to signal the presence of radiation.
- These monitoring systems have become a basic part of radiation protection programs and include instruments to warn when permissible levels are exceeded for the individual and to measure exposure levels

Personnel monitoring is accomplished by two types of instruments:

1. Those that are read directly and
2. Those that require supplemental processes or readings and are a measure of exposure levels over a period of time.
   - Examples of direct reading instruments are the chemical dosimeter, pocket ionization chambers, and the hand-and-foot counter.
   - Instruments that require supplemental processes or readings are the film badge and the glass dosimeter.

2.6.8 Radiation Measurement

Roentgen (R)- Describes a radiation field in terms of the amount of ionizations produced in air, not in common use today

Rad- Conventional unit of absorbed dose of radiation per unit mass.

Gray (Gy) – 1 Gray=100 Rads

Rem- Absorption measure to whole body or specified organ, takes into account radiation quality, Rem=rads x quality factor, each type of ionizing radiation has a different quality factor

Sievert (Sv)- 1SV=100 Rem

Ionizing Radiation Exposure Limits

Occupational- National Council on Radiation Protection (NCRP) annual exposure 5 rem Background Exposure for a US resident is 360mrem

Common Occupational Exposures-

- Medicine- Radionuclides, X-Ray
- Nuclear Power Industry
- Document Dating
- Food Preservation

- Airplane/Space Flight
- Transportation of Radioactive Material

Four Ionizing Radiation Exposure Categories-

1. Radioactive Contaminates on Intact Skin
2. Local Radiation Injuries
3. Whole Body Exposure
4. Internal Deposition

Acute Radiation Syndrome

- Over 100 rad in a single exposure or within 24-48 hours, progressive predictable series of signs and symptoms developing over a period ranging between a few hours to several weeks
- Clinical response and prognosis generally depends on damage sustained by hematopoietic system.
- Lethal dose for 50% of healthy humans is 350 to 450 rad (3.5 to 4.5 Gy)

Prodromal Period- 1 to 6 hours after exposure

- Anorexia, Nausea, Vomiting, Diarrhea
- Initial Symptoms subside after a few hours to two days
- Ominous signs include diarrhea, skin erythema, lymphocyte count less than 1000, short or no latent period

Latent Period- Variable in duration hours to 30 days

Manifest Illness

Fatigue, GI symptoms, desquamation, deep ulcerations, bone marrow depression, Stomatitis, hemorrhagic phenomena

Death or Recovery

CBC normalizes in six months to a few years, Clinical recovery within 6 months,persistent fatigue

Long Term Effects

- Chronic Radiodermatitis
- Cataracts
- Sterility
- Prenatal Effects
- Cancer
- Genetic Effects
- Shortened Life Span

2.7 Management of Radiation Exposures

1. Radioactive Contaminates on Intact Skin- Wash skin, do not break skin
2. Local Radiation Injuries- Estimate whole body exposure, wound care, nutritionalsupport, analgesics, infection control, consultation
3. Whole Body Exposure

   100 rem or less-
   - Complete history for record
   - Advise regarding potential late effects (cancers) Follow as outpatient, counseling

   100 rem to 200 rem
   - Complete exposure history radiation source and strength
   - Consider Lab testing CBC with diff

   200 rem to 300 rem
   - Hospitalized

   300 rem or more
   - Transfer to Tertiary Care Center Supralethal exposure of more than 5000 rem
   - Supportive care at any hospital will do
   - Will die in a few days

4. Internal Deposition

   Reduce Absorption- Binding Agents, AntacidsExpedite Elimination- Cathartics Organ Saturation- Potassium Iodide Displacement- Calcium, Iodide Chelation

2.8 Industrial Hygiene:

Keeping Workers Healthy and Safe

Organizations are responsible for the overall health and safety of the workers they employ, from warehouse workers to the executive suite at their desks. Keeping employees safe and healthy requires knowledge of industrial hygiene, which is the science dedicated to the anticipation, recognition, evaluation, communication, and control of environmental stressors in the workplace that may result in injury, illness, impairment, or otherwise affect the wellbeing of workers and community members[1].

Because industrial hygienists are trained to evaluate safety concerns and find solutions to problems, it is important that managers at all levels and across functions are able to effectively work with and manage industrial hygienists. Whether you have an industrial hygienist on your team or you have to hire an outside company for an assessment, being able to speak the language of industrial hygienists will allow you to have a deeper understanding of potential health and safety issues. In addition, once an industrial hygienist has recommended a course of action to correct any real or potential issues, you will be the one responsible for ensuring they are implemented in your workplace.

- This topic is concerned with hazards that largely are unseen by the unaided eye.
- They are responsible for the organic injuries which, if arising out of and in the course of employment, are commonly called occupational diseases
- Until the enactment of the Occupational Safety and Health Act (OSHA), work injuries and work diseases were regarded more or less as separate problems.
- Work injuries occurred suddenly and their agent (i.e., the machine, work surface, tool, and so on, most closely associated with the injury) usually was readily evident
- These long-term exposures may eventually lead to a chronic disease that is usually irreversible
- An example is the class of occupational diseases known as pneumoconioses (diseases of the lungs), which are produced by the long- term inhalation of respirable particles of dust such as silica
- Short-term or acute exposures usually refer to high exposures to a toxic substance over a short period of time, resulting in an acute effect that is an illness from which the individual usually recovers without a permanent effect.
- The role of the modern day industrial hygienist has changed dramatically over the years, stimulated by the passage of the Occupational Safety and Health Act in 1970 and the increased emphasis, especially since 1976, on industrial health.
- In addition, public awareness and union involvement has contributed to the expansion and growth of the field.
- American Industrial Hygiene Association (AIHA) as "that science and art devoted to the anticipation, recognition, evaluation, and control of those environmental factors or stresses arising in or from the workplace which may cause sickness, impaired health and well-being, or significant discomfort and inefficiency among workers or among citizens of the community
- The U.S. Labor Department's Bureau of Labor Statistics reported 126,100 cases of occupational illnesses in 1981, compared to 130,200 in 1980.
- The reduction was encouraging, but the figures did not include cancer and other chronic diseases because of the problems of detection and recognition

- Protection from exposure to toxic substances in the workplace is provided for in provisions of the Occupational Safety and Health Act of 1970.
- The concern of the act is to ensure safe and healthful working conditions for working men and women.
- *National Institute for Occupational Safety and Health (*NIOSH) is authorized to make inspections, question employers and employees, and make contractual arrangements with public and private organizations for these studies.
- Unlike OSHA, however, NIOSH is not empowered to take legal action when it finds hazardous exposure in workplaces.
- OSHA and NIOSH are authorized to cooperate in these studies and to disseminate their findings to all affected parties

2.8.1 Key Components of Industrial Hygiene

Industrial hygiene encompasses a wide range of health and safety concerns in the workplace. As a manager, you should be familiar with the basics of most of them. Here are some, though not all, of the key components of industrial hygiene.

- **Ergonomics:** The goal of ergonomics (the study of people at work), is to reduce stress and eliminate injuries associated with bad posture, overuse of muscles, and repeated tasks. For example, proper ergonomics can help prevent carpal tunnel syndrome, tendonitis, and lower back injuries. While performing an ergonomics intervention, it’s important to involve workers in the process to ensure tasks are fit to the worker and workers are properly trained on aspects such as how to lift boxes correctly. Ergonomics can be improved through solutions such as changing the chairs or keyboards office workers use, introducing tools to reduce repetitive tasks, or limiting time on certain jobs.

- **Noise:** Long-term exposure to noise – both wanted and unwanted sound – can lead to hearing loss for workers. Noise issues can be addressed in several ways, including designing a facility to minimize noise, separating workers from noisy machinery as much as possible, and using devices, such as ear muffs or ear plugs, to protect workers.

- **Temperature:** Both high and low temperatures can cause problems for workers. If temperatures are too high, workers are vulnerable to heat stroke or heat exhaustion; heat stroke is a medical emergency that requires immediate attention. Workers should be allowed to slowly adapt to the heat (acclimatization) and drink small amounts of water frequently, and air should be cooled whenever possible. Prolonged exposure to low temperatures can lead to hypothermia or frostbite. Workers should be allowed to wear warm clothing, and take breaks in warmer temperatures when possible.

- **Indoor air quality:** Indoor air quality can be impacted by many factors, including pollution from machines or tools inside the building, highway pollution outside the building, dusts from mechanical processes, or gasses. Poor air quality can cause issues ranging from chronic coughs to nausea to severe headaches. Proper ventilation is important to ensure that fresh air is brought into the work area and air filtering in an HVAC system can help remove contaminants from the air.

- **Chemical exposure:** Chemical hazards can take many forms, from liquid to fumes to dusts, and can be absorbed, inhaled, or ingested into a worker's system. Some common chemicals that can potentially be hazardous are cleaning products, gasoline, and pesticides. Many chemicals can be harmless in small doses, but even some common chemicals can cause symptoms in those who are particularly sensitive, and most chemicals can cause adverse effects in large doses or when proper safety precautions are not taken. These precautions include ventilation, personal hygiene such as hand washing, which can reduce the amount of chemicals absorbed by the skin, and maintaining equipment in order to prevent leaks and breakdowns.

- **Radiation:** There are two types of radiation – non-ionizing radiation and ionizing radiation. Ultraviolet (UV) radiation and laser radiation are the types of non-ionizing radiation most likely to cause safety concerns, usually burns, for workers; UV radiation is a particular problem for outside workers, such as gardeners. Ionizing radiation can cause more considerable health risks for workers, and can be found in settings ranging from health care facilities to nuclear reactors and their support facilities. This type of radiation damages cells, and possible long term effects include cancer and sterility. Exposure to ionizing radiation should be limited as much as possible, and workers should be shielded from radiation by materials such as lead or concrete.

- **Biological hazards:** Living organisms such as fungi, viruses, and bacteria, can enter the body and cause both acute and chronic infections. Workers who deal with plants or animals and laboratory or medical workers are particularly at risk for biological hazards, but all workers can be at risk for hazards such as mold, and bacteria that cause Legionnaire's disease. Proper hygiene such as hand washing, ventilation, personal protective equipment such as gloves or respirators, and in certain cases, isolation of the hazard, can all help minimize the risks associated with biological hazards.

- **Eliminating or Controlling Hazards:** Once hazardous conditions have been identified there is a systematic approach to eliminating or minimizing the potential hazard. This starts with designing the hazard out of the process or operation, providing local exhaust ventilation, establishing proper work practices, providing proper personal protective equipment (PPE) and applicable administrative measures.

2.9 Industrial Toxicology

Definition

Industrial toxicology is the study of the harmful effects on humans by chemicals used in the workplace, the products produced by companies, and the wastes created in manufacturing

Description

Industrial toxicology is a division of the broader science of toxicology that deals with the adverse effects of all forms of chemicals, physical agents, and processes, including drugs and medications. Originally, toxicology was known as the study of poisons, a focus that marked this science since its earliest beginnings. Only in the middle of the twentieth century did this area of scientific inquiry expand and become more specialized.

- The word toxicology is derived from the Greek word for the poison that arrows were dipped in.
- Toxicology is the science that deals with the poisonous or toxic properties of substances.
- A toxic effect can be defined as any noxious effect on the body, reversible or irreversible; any chemically induced tumor, any mutagenic effect, or death as a result of contact with a substance via the respiratory tract, skin, eye, mouth, or any other route
- Toxic effects are undesirable disturbances of physiological function caused by poisons
- It is a physiological property that defines the capacity of a chemical to do harm or produce injury to a living organism by other than mechanical means
- They may not injure the organ through which they enter the body.
- They may trigger an immediate bodily response or a response years later.
- Industrial poisons may enter the body by ingestion (swallowing), inhalation, or absorption through the skin.
- primary consideration in the control of industrial health hazards is the workroom air.
- Occupational Safety and Health Act, limits have been established for the air contaminants most frequently found in work environments
- Threshold Limit Values," published by the American Conference of Governmental Industrial Hygienists
- Standards of Acceptable Concentrations of Toxic Dusts and Gases," issued by the American National Standards Institute
- In the case of some materials a greater concentration of exposure than the limit value specified in the regulations for an 8-hour shift in a 40-hour week
- exposure to a contaminant may not exceed the limit value specified for it
- Air contaminant values are useful as a guide for determining conditions that may be hazardous and may demand improved control measures.

Acute and Chronic Poisoning

The **Acute poisoning** from a single exposure to a heavy concentration of a toxic substance.

The **Chronic Poisoning** is the result of repeated exposures to smaller concentrations

For example, exposure to a concentration of 10 parts per million of carbon tetrachloride for repeated prolonged periods may cause serious physiological damage; this would be a chronic poisoning.

2.9.1 Forms of toxicity

Industrial chemicals that cause the most harm to the body are classified as irritants, asphyxiants, and systemic poisons. Generally, each grouping corresponds to a common route of entry: the skin and eyes, the lungs, and the digestive system. These sites are the places where absorption of the chemical occurs.

IRRITANTS. Irritants are substances that cause inflammation, rashes, or corrosion of skin. They can also cause pain, swelling, mucus secretion, and muscle constriction. These chemicals can also irritate the lining of lungs and the digestive system, and are called irritants because the corrosive effects occur on epithelial (skin) cells within these organs. Irritants also include gases such as chlorine, ammonia, and formaldehyde. These chemicals can cause coughing, fluid build up in the lungs, and pain.

Another group of irritants called particulate irritants are composed of minute bits of material produced within the work environment. Pulmonary fibriosis, a common condition for those exposed to these irritants in mining and manufacturing, results in scarring of the lungs, and often disability and death. Coal miners are exposed to silica, which can result in pneumoconiosis, silicosis (black lung disease), and asbestosis.

ASPHYXIANTS. Asphyxiants are aerosols or airborne chemicals that are inhaled through the mouth and nose. These chemicals displace oxygen within the lungs, thus inhibiting the amount of oxygen being transported throughout the body to nourish cells. Nitrogen and helium, used to flush vats and tanks before routine maintenance, are examples of simple asphyxiants. They replace oxygen in the atmosphere surrounding a worker.

SYSTEMIC POISONS. Systemic poisons are chemicals that are ingested and absorbed by the digestive tract. They are grouped according by their action or by a specific organ of the body that they target. Narcotics and anesthetics reduce central nervous system function, and include organic solvents that make effective anesthetics. One such solvent, diethyl ether, was taken out of the industrial sector and used in surgical procedures because of its anesthetic uses. Other neurotoxic agents may cause irreversible damage to the central or peripheral nervous system and include alcohols, mercury, carbon disulfide, and organometallics, such as tin used in antifungal coatings. Some chemicals, such as organic solvents and some metals, target the kidneys and liver. Since these organs are the body's toxin filters, they have more contact with ingested poisons and suffer greater damage. Another group of systemic poisons, include benzene, lead, and arsenic, which affect the bone marrow and can produce too few red blood cells (anemia) or too many white blood cells (leukocytosis). Certain agents, such as mercury, lead, and carbon disulfide, target reproductive organs. They can alter male fertility or cause spontaneous abortion. Mercury has been linked with birth defects.

What is a Toxicant?

A toxicant is any chemical that can injure or kill humans, animals, or plants; a poison.

The term “toxicant” is used when talking about toxic substances that are produced by or are a by-product of human-made activities.

What is a Toxin?

The term “toxin” usually is used when talking about toxic substances produced naturally.

A toxin is any poisonous substance of microbial (bacteria or other tiny plants or animals), vegetable, or synthetic chemical origin that reacts with specific cellular components to kill cells, alter growth or development, or kill the organism.

What is a Toxic Symptom?

This term includes any feeling or sign indicating the presence of a poison in the system.

What are Toxic Effects?

This term refers to the health effects that occur due to exposure to a toxic substance; also known as a poisonous effect on the body.

What is Selective Toxicity?

“Selective toxicity” means that a chemical will produce injury to one kind of living matter without harming another form of life, even though the two may exist close together.

How Does Toxicity Develop?

Before toxicity can develop, a substance must come into contact with a body surface such as skin, eye or mucosa of the digestive or respiratory tract. The dose of the chemical, or the amount one comes into contact with, is important when discussing how “toxic” an substance can be.

2.9.2 Important points for storage of toxic materials.

1. Every chemical should have an identifiable storage place and should be returned to that location after use.
2. A storage scheme must be developed in each chemical storage area to ensure the segregation of incompatibles and efforts must be made to isolate particularly flammable, reactive, and toxic materials. An exclusively alphabetical storage scheme is prohibited.
3. Chemical storage on bench tops will be minimized in order to reduce the amounts of chemicals unprotected from a potential fire or easily knocked over.
4. Compatible chemicals should be grouped by container size to make it easier to retrieve chemicals and to reduce the possibility of bottle breakage.
5. Chemical storage in hoods will be minimized. Storing containers inside the hood interferes with airflow, reduces and clutters up the work space, and provides fuel in a fire or explosion. Where possible, chemicals will be stored in separate cabinets which vent directly into the fume hood.
6. Labels must be maintained on all stored materials.
7. Stored chemicals must not be exposed to direct sunlight or heat.
8. Storage trays should be used to minimize the spread of a spill.
9. Laboratory refrigerators must never be used to store food.
10. All chemicals containers left out of storage areas must be checked at the end of each workday. Unneeded items must be returned to chemical storerooms or stockrooms.
11. Store acids (inorganic and some organic acids) in a dedicated acid cabinet. Oxidizing acids must be isolated from other acids (i.e., each in its own separate secondary containment).
12. Store flammables in a dedicated flammables cabinet. Acetic acid and acetic anhydride must be stored in a flammable cabinet.
13. Store highly toxic chemicals in a dedicated cabinet.
14. Opening/expiration dates must be assigned to chemicals with the following functional groups/chemical properties: a. Picric acid and Picrates b. Perchlorates c. Peroxides d. Peroxidizable materials (aldehydes, ethers, compounds containing benzylic hydrogen atoms). Peroxidizable materials must be tested routinely for peroxides e. Monomers that polymerize violently or become hazardous after polymerization f. Other materials known to deteriorate or become unstable or reactive over time

15. All laboratory personnel, on termination, transfer, or graduation must (in conjunction with the laboratory supervisor and CHO) arrange for the redistribution, removal or safe storage of all hazardous materials remaining in their laboratory.
16. Appropriate spill control, clean-up and emergency equipment must be available wherever chemicals are stored. See Chapter 8 for guidance in choosing these materials.

◆

UNIT – 3

ENVIRONMENTAL CONTROL

UNIT – 3

ENVIRONMENTAL CONTROL

3.1 Industrial Health and Safety Hazards

Safety hazards appear while an employee works. Examples of safety hazards include shocks from faulty electrical equipment, slips on floors, falls from working at heights, head injuries from falling debris and cuts or worse from improperly used machinery.

3.2 Methodologies to Protect Workers

1. Require Personal Protection Equipment

Safety equipment separates workers' bodies from hazards in the workplace, which reduces the chances of injuries. Personal protection equipment, PPE, includes hardhats, goggles, hearing protection, gloves and respirators. By requiring appropriate PPE, your company can prevent injuries from exposure to chemicals, biological agents, noise, radiation and accidents.

OSHA requires that you supply safety equipment for your workers. Regularly check the integrity of the PPE you provide and replace any that shows signs of wear or damage. A broken hardhat will not protect a worker from a head injury the same as an intact one will.

2. Train Employees

Employees cannot practice safety measures they do not know about. Establish a culture of prioritizing safety that includes regular training and safety updates to keep all employees on the same page. Frequently scheduled training sessions remind workers of the safety steps they must take to avoid accidents and other hazards. When employees have regular reminders, they will likely not become complacent or lax in their work, which can lead to forgetting vital steps in preventing hazardous situations. During the training sessions, ask workers what they need from your business to feel safer on the job. They have first-hand experience and know best the hazards they face.

3. Prevent Falls

Protecting workers from falls requires using the proper guardrails and barriers to keep them out of dangerous areas. Keep floors clean and dry to prevent slips and encourage appropriate non-skid footwear for all employees. OSHA takes falls very seriously, which is why the organization has such strict requirements for employers to prevent these accidents. OSHA requires your company provides a worker with as hazard-free an environment as possible, keeps floors dry and provides PPE including harnesses to prevent falls and trains workers.

4. Enforce Safety

Setting out safety measures only covers part of the equation of protecting your company’s workers. Your company’s industrial safety system must include a means of enforcing the safety guidelines you establish. Do not let OSHA serve as the only enforcer of safety at your business. Take charge in preventing accidents by having regular checks of the floor and watching for whether employees are using proper safety procedures.

Consider a reward system to encourage workers to take the required steps to be safe instead of a punishment system that metes out demerits for breaking safety rules. With rewards, workers will feel more appreciated, cementing their loyalty to your business and possibly increasing their productivity.

5. Maintain Electrical Equipment

Poorly maintained electrical equipment poses a serious hazard to operators. Regularly servicing electrical equipment will prevent accidents caused by worn-out wires and other mechanical failings that can cause electrocutions. Instead of waiting for a problem to occur, conduct preventative maintenance and schedule repairs as soon as something minor happens.

Ensure operators and service crew always use the proper procedures for lockout/tagout. Following OSHA’s lockout/tagout procedures will keep workers away from hazardous electrical sources and prevent up to 120 annual fatalities and 50,000 injuries.

3.3 Seven Common workplace hazards.

The 7 common workplace hazards are:

1. Safety hazards
2. Biological hazards
3. Physical hazards
4. Ergonomic hazards
5. Chemical hazards
6. Work organization hazards
7. Environmental hazards

1. Safety hazards

Safety hazards are number one on the list of 6 types of workplace hazards. These hazards play an effect on employees who work directly with machinery or on construction sites. Safety hazards are unsafe working conditions that can cause injury, illness, and death. According to the National Safety Council, in 2016, 34,673 people in North America have died in falls at home and at work. Safety hazards are the most common workplace risks. They include:

- Anything that can cause spills or trips, such as cords running across the floor or ice
- Anything that can cause falls, such as working from heights, including ladders, scaffolds, roofs, or any elevated work area.
- Unguarded and moving machinery parts that a worker can accidentally touch.
- Electrical hazards like frayed cords, missing ground pins, and improper wiring
- Confined spaces.

2. Biological hazards

The definition of biological hazards, commonly known as biohazards, can be any biological substance that could cause harm to humans. Biological hazards include exposure to harm or disease from working with animals, people, or infectious plant materials. Workplaces with these kinds of safety hazards include, but are not limited to, work in schools, daycare facilities, colleges and universities, hospitals, laboratories, emergency response, nursing homes, or various outdoor occupations.

Types of things you may be exposed to for biological hazards:

- Blood and other body fluids
- Fungi/mold
- Bacteria and viruses
- Plants
- Insect bites
- Animal and bird droppings

To learn more about biological hazards, we dive deeper into our other blog articles:

- Biological hazards in the home
- Workplace Hazards Series: Biological Hazards

3. Physical hazards

Of all the hazards in your workplace, physical hazards might be the least obvious. Despite their name, physical hazards aren’t always something that you can see or touch. Physical hazards affect workers in extreme weather conditions or harmful working environments. Workers who are exposed outside in the sun for a prolonged period of time can suffer physical hazards which can cause long-term effects to their health. Physical hazards can be any factors within the environment that can harm the body without necessarily touching it.

Physical hazards include:

- Radiation: including ionizing and non-ionizing (EMF’s, microwaves, radio waves, etc.) materials

- High exposure to sunlight/ultraviolet rays
- Gases under pressure
- Temperature extremes – hot and cold
- Constant loud noise

Read more about physical hazards in our workplace hazard series.

4. Ergonomic hazards

Ergonomic safety hazards occur when the type of work, body positions, and working conditions put a strain on your body. They are the hardest to spot since you don’t always immediately notice the strain on your body or the harm that these hazards pose. Short-term exposure may result in “sore muscles” the next day or in the days following the strain, but extended exposure can result in serious long-term issues.

Ergonomic Hazards include:

- Improperly adjusted workstations and chairs
- Frequent lifting
- Poor posture
- Awkward movements, especially if they are repetitive
- Having to use too much force, especially if you have to do it frequently
- Excessive vibration

To learn more about ergonomic hazards, we dive deeper into our other blog articles:

- Workplace Series: Ergonomic Hazards

Methods to Know Ergonomic hazard

The severity of ergonomic hazards often depends on the level of exposure over time. Injuries sustained from these safety hazards can include anything from sore muscles to long-term illnesses. Ergonomic hazards include:

- Improperly adjusted workstations and chairs
- Frequent lifting
- Poor posture
- Awkward movements, especially if they are repetitive
- Using too much force, especially if it’s done frequently
- Vibration

Ergonomic hazards are often a result of the way a space is designed, meaning that planning ahead and thinking about how employees interact with their work space is crucial.

5. Chemical hazards

Chemical hazards are present when a worker is exposed to any chemical preparation in the workplace in any form (solid, liquid or gas). Some are safer than others, but to some workers who are more sensitive to chemicals, even common solutions can cause illness, skin irritation, or breathing problems.

Chemical hazards can be present in the following:

- Liquids like cleaning products, paints, acids, solvents – particularly if hazardous products are in an unlabeled container
- Vapors and fumes that come from welding or exposure to solvents
- Gases like acetylene, propane, carbon monoxide, helium, h2s gas
- Hazardous products and flammable materials like gasoline, solvents, and explosive chemicals
- Pesticides

6. Work organization hazards

Safety hazards or stressors that cause stress (short-term effects) and strain (long-term effects). These are hazards associated with workplace issues such as workload, lack of control and/or respect, etc.

Examples include:

- Workload demands
- Workplace violence
- High intensity and/or pace
- Respect (or lack thereof)
- Flexibility
- Control or say about things
- Social support or relations
- Sexual harassment

7. Environmental hazards

Last but definitely least are environmental hazards which are constantly changing with increasingly unpredictable – and extreme – weather and climate. The bad news is that they are mostly out of our control, but the good news is weather challenges and hazards are somewhat predictable with the change in seasons and advances in meteorology.

Examples include:

- Extreme temperatures (dangerous heat and cold)
- Extreme precipitation (rain and snow)
- Dangerous levels of noise
- Dangerous levels of radiation
- Pollution (air and chemical)
- Unstable infrastructure
- Biological hazards
- Violent members of the public
- Dangerous animals

3.4 Administrative vs. Engineering controls

Engineering controls limit risk by reducing or eliminating safety hazards through physical means. Examples of engineering controls for ergonomic hazards include:

- Breaking down tasks and weight loads to reduce the exertion necessary by employees
- Limiting employee exertion by using equipment for heavy lifting
- Redesigning work spaces to accommodate individuals in order to reduce strain and improve posture
- Ensuring that all work spaces provide employees the full range of motion required to complete a task
- Repositioning objects and surfaces such as tables in the workplace to reduce the need for reaching

Administrative controls reduce risk by changing work processes and activities in order to make them more safe. Some examples of administrative controls for ergonomic hazards are:

- Provide employees with break periods that help to reduce short-term strain
- Adjusting the pace of work to reduce exertion
- Rotate employees working in repetitive or strenuous tasks, to reducing exposure
- Store objects and tools where employees can retrieve them while maintaining neutral position
- Label any heavy loads with their weight amount
- Place requirements on weight loads by introducing group lifting policies

3.5 Office Safety: Designing a Safe and Functional Office

Without a properly functional workspace, the possibility of ergonomic hazards in the workplace increases. They are the hardest to spot since you don’t always immediately notice the strain on your body or the harm that these hazards pose. Short-term exposure may result in “sore muscles” the next day or in the days following the exposure, but long-term exposure can result in serious long-term illness. Ergonomic hazards can not only affect the worker: the employer can suffer slower productivity, lower morale in staff, and higher disability and insurance claims. Safety and comfort should be considered equally to visual aesthetics when it comes to designing workspaces. Learn how to design safe and functional office space in this article. Keeping a safe work environment involves thoughtfully choosing the interior materials, lighting, and layout. It also includes ensuring the workspace that you spend the majority of your time in is designed to support a neutral ergonomic position for your body to prevent chronic pain and discomfort. In addition to these physical elements, staff members should take measures to ensure cleanliness and develop emergency protocols to keep all members safe in the workspace.

Office safety: create a safe workspace by considering these three elements:

1. Ergonomics
2. Environment
3. Safety Protocols

1. Ergonomics

How your work environment is arranged can have huge long-term effects on your body. A properly set up desk is a good way to prevent injury and create a more comfortable space for prolonged working. How to set up your workspace: Your joints should be as close to 90% as possible to create a neutral seated position. **Tip**: If you need to raise your chair to accommodate the standard desk height, you can also raise your feet. If possible, standing up frequently and looking away from your computer monitor may also increase comfort at your workstation.

2. Work environment

There are steps that you can take to ensure and safe office environment. This may involve the interior design of an office and also the procedures enforced among the office staff to maintain the office. Layout: It is important to have a well-laid-out office space with ample walkways and clear means of egress. If an emergency does happen, it is imperative that all staff can reach an emergency exit easily and quickly. Lighting: Designers consider lighting an important safety element within an office. It is important to have enough light to avoid trips and falls.

- Corridors and stairwells also require ample lighting for quick exiting and to avoid trips as well.

- Well-lit garages and entrances result in fewer high-risk zones for attacks.
- Enough light at a workspace will also help to avoid accidents and eye fatigue.

Materials: appropriate materials should be selected throughout an office space.

- Anti-slip materials should be used where people are walking.
- Anti-slip or grip tape maybe use on stair treads and very high traffic areas.
- Walk-off mats at the entrances of buildings serve to eliminate slipping caused by wet shoes.

3. Safe protocols to uphold

The office staff can ensure safety by enforcing protocols within the work environment. Education: Safety leaders can enforce education that provides awareness of emergency action plans such as exit routes and safety meeting locations. Workspace: Staff can be upheld to a clean workspace to ensure a safe exit path from the building. Knowledge: Having staff with first aid training could prevent serious long-term injury to employees and may even save lives. Custodial protocol: Ensuring that spills are cleaned up promptly and proper warning signs are used for wet areas to avoid slips and falls. Creating a safe work environment involves the thoughtful use of the design of interior materials, lighting, and layout. Your workspace should also support a neutral ergonomic position for your body in order to prevent chronic pain and discomfort. In addition to these physical elements, staff members should take measures to ensure cleanliness and develop emergency protocols to keep all members safe in the workspace.

3.6 Environmental control

To achieve this controlled environment, it is necessary to have such mandatory industry ambiance settings.

- ensure compliance with current legislation, industrial, corporate and local regulations governing the Company's activities in the field of industrial safety, occupational health and the environmental protection, as well as other external requirements in the field of industrial safety, occupational health and environment protection, which the Company has undertaken to perform;
- carry out the identification and assessment of industrial hazards and risks, perform management activities, reducing industrial risks;
- identify and eliminate harmful factors in the workplace;
- take measures to prevent pollution of the environment;
- give due consideration to the complex of pre-emptive measures to prevent the possibility of emergency situations, and if they occur, to take measures to reduce the consequences of emergency for the environment;
- develop and adopt a set of measures for the prevention of occupational accidents and diseases;

- provide training and development of the Company’s employees in the field of industrial safety, occupational health and environment protection;
- bind contractors engaged in the production facilities of the Company to comply with applicable requirements of the Company for industrial safety, occupational health and environment protection;
- improve the working methods in the implementation of the Company's policy in the field of industrial safety, occupational health and environment protection.

3.7 Industrial Noise Control

In any work environment, there can be many reasons to keep sound levels within a reasonable range. Sound levels above this range are perceived as "noise." Noise can distract the workforce, creating an unsafe workplace. Or, worse yet, it can cause hearing loss.

A worker distracted by noise may become less production and even irritable. If noise levels are too loud, the worker may not be able to hear warning signals or instructions. High noise levels over prolonged periods of time can lead to permanent hearing loss. When any of these conditions exists, it is important to control, contain, reduce, or eliminate the noise source so a safe work environment can be maintained.

3.7.1 Negative Effects of Noise Pollution

Intense and unpleasant noise can lead to psychological trauma, resulting in neurological problems and nervous disorders. A 2004 study that investigated sawmills, printing presses, and corn mills for industrial pollution, found that the noise levels in these industries often exceed 85dBA. 23% of the corn mill workers, 20% of the sawmill workers, and 7.9% of the printing industry employees showed symptoms of noise-induced hearing loss. Other workers, who were exposed to hazardous noise showed clear signs of hearing impairment and other related issues.

Other effects of industrial noise pollution include:

- **High blood pressure**
- **Stress & anxiety**
- **Fatigue**
- **Anger issues**
- **Communication difficulties**
- **Headaches**
- **Sleep disturbance**
- **Productivity loss**

How to Reduce Noise Pollution?

We can reduce noise Pollution by following below mentioned Tips:

- **Turn off Appliances at Home and offices**

We can turn off home and office appliances when not in use such as TV, games, computers etc. it can create unnecessary stress on ears. We can save electricity also when we turn them off.

- **Shut the Door when using noisy Machines**

We can shut the door after we turn on dishwashers or washing machines for rooms where it is kept or we can turn them on before leaving the house so that overlapping of exposure to loud noises can be reduced

- **Use Earplugs**

Fig. 3.1 Earplugs

Use of earplugs or earmuffs can bring down loud noises to a manageable level. Earplugs are small inserts that fit into our ear canal. And earmuffs fit over the entire outer ear to form an air seal keeping ears safe from loud noises.

- **Stay away from Noisy area**

Noise producing industries, airports, vehicles should be far from residential areas as it is very dangerous for infants and senior citizens.

- **Follow the Limits of Noise level**

Community law should check the use of loudspeakers, outdoor parties as well as political public announcements.

- **Control Noise level near sensitive areas**

There should be control on noise level (Silent zones) near schools, hospitals. Place noise limits boards near sensitive areas.

- **Go Green by planning trees**

Fig. 3.2 Green Plantation

We can plant more trees as they are good noise absorbents. According to studies, it can reduce noise by 5 to 10 decibels Db around them.

- **Create Healthy noise to eliminate unwanted noise**

If we can’t eliminate unwanted noise coming from outside then we can create healthier noise such as music, singing birds or waterfalls in homes or offices.

- **Use Noise absorbents in noisy machineries**

We can check for pieces of machinery which are creating noise due to vibrations and put some noise absorbents to reduce noise.

- **Use Proper Lubrication and Better maintenance**

Fig. 3.3 Mechanical oil Lubrication

We can use proper lubrication as well as better maintenance of machines to reduce noise pollution and improve efficiency. It reduces friction between movable parts and helps to reduce noise.

- **Notify Authorities about Disobedience of Noise Rules**

We can notify government agencies if someone is not following rules and regulation regarding noise levels.

Regularly check noise levels

Regularly checking noise level in an industrial complex and indoor to keep noise level within the limit.

Fig. 3.4 Noise Free Zone

It is necessary to control the noises created around us. It is necessary to aware people around us through various mediums. We can start from ourselves to spread awareness about noise pollution and its effects on human and the environment. Limit for noise at daytime is 55 dB and in the night it is 30 dB to avoid health effects.

3.7.2 Noise Measurement

Noise level is measured in decibels (dB). The louder the noise, the higher the decibels. Decibels can be adjusted to human hearing. Noise level is thus described in decibels A (dBA). The effects of noise vary with the noise to which a person is exposed. Prolonged exposure to loud noises (75 dBA over eight hours a day for years) can lead to hearing loss. The body can also respond to lower noise levels: sleep can be disturbed by an outdoor noise of 40 dBA.

Examples of Noise Sources and Human Responses by Noise Level

0 dBA

Example of noise:

no sound is perceptible.

Human reaction:

the threshold of hearing. **10 dBA**

Example of noise:

breathing.

Human reaction:

the sound is barely audible. **20 dBA**

Example of noise:

whispers heard a metre away; light wind in trees.

Human reaction:

a sense of deep calmness. **30 dBA**

Example of noise:

a low-voice conversation.

Human reaction:

a sense of calmness. **40 dBA**

Example of noise:

library, refrigerator, a quiet street at night.

Human reaction:

a peaceful area. **50 dBA**

Example of noise:

moderate rain, washing machine.

Human reaction:

the beginning of disturbance. **60 dBA**

Example of noise:

normal conversation. **70 dBA**

Example of noise:

busy street, vacuum cleaner.

Human reaction:

disruptive when on the telephone. **80 dBA**

Example of noise:

alarm clock, factory, noisy restaurant.

Human reaction:

difficult to have a conversation; a feeling of heavy noise. **90 dBA**

Example of noise:

subway, lawnmower, alarm.

100 dBA

Example of noise:

drill, chainsaw, motorcycle. **110 dBA**

Example of noise:

loud concert, club.

Human reaction:

bearable for a short period of time; maximum vocal effort to be heard. **120 dBA**

Example of noise:

emergency vehicle siren, airplane takeoff heard from about 300 metres.

Human reaction:

beginning of pain. **130 dBA**

Example of noise:

jackhammer, pneumatic tool.

Human reaction:

pain. **140 dBA**

3.8 Industrial Personal Protective Equipment (PPE) Equipment Overview

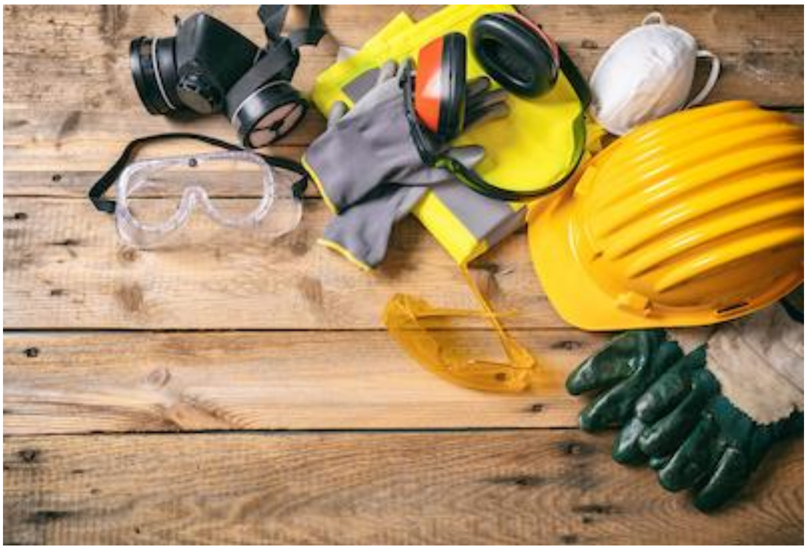


Fig. 3.5 Industrial Personal Protective Equipments

A Personal Protective Equipment (PPE) is clothing or equipment designed to reduce employee exposure to chemical, biological, and physical hazards when on a worksite. It is used to protect employees when engineering and administrative controls are not feasible to reduce the risks to acceptable levels.

Personal Protective Equipment (PPE) is tools and accessories worn to guarantee users' safety and health protection. Typically, PPE is worn when there's a risk of exposure to health and safety hazards. Workers wear industrial PPE to protect themselves from physical, mechanical, electrical, and other workplace hazards in an industrial setting.

Industrial PPE consists of any clothing or work accessories designed to protect against workplace hazards. Nonetheless, wearing the accessories does not eliminate the risks, and if the accessories fail, exposure will undoubtedly occur. That said, here's an overview of industrial personal protection equipment

Importance

According to the hierarchy of controls by the National Institute for Occupational Safety and Health (NIOSH), PPE (sometimes also reffered to as PPE equipment)—is recommended to be the last level of defense to prevent occupational injuries, illnesses, and fatalities, but some businesses combined it with other control measures to ensure a safe and healthy environment for their workers. Here are some benefits of using PPEs:

- prevent unnecessary injury in the workplace;
- protect employees from excessive chemical exposure;
- prevent the spread of germs and infectious diseases including COVID-19;
- help businesses comply with regulatory requirements(e.g., The Personal Protective Equipment at Work Regulations 1992 that’s recently been extended to limb workers); and
- improve employee productivity and efficiency.

3.8.1 Types of PPE (Personal Protective Equipment)

The Occupational Safety and Health Administration (OSHA) mandates employers to assess their workplaces and determine whether the hazards require eye, face, hand, foot, or head protection.

Head PPE Equipment

Fig 3.6 Head Protective Equipment

Head equipment protects against impact blows to the head. Helmets come in different classes and don't offer the same level of protection. So, finding a helmet type suited to the work environment is highly important. The American National Standards Institute (ANSI) categorizes helmets into different types and categories:

- **Type 1:** These are helmets with a full brim more than 1¼ inches wide around the entire hat

- **Type 2:** These helmets come with a short brim that extends forward from the crown
- There are three electrical performance classes:
- **Class A:** protects the head against low-voltage electrical conductors, impact, and penetration. Helmets get proof-tested at 2,200V of electric charge for certification purposes.

- **Class B:** These are utility service helmets, and they protect against penetration, impact, and high-voltage electrical conductors. Proof-testing for class B occurs at 20,000V.

- **Class C:** Class C helmets are typically made from aluminum and only offer penetration and impact protection. Thus, they should not be used in areas with electrical hazards.
- The voltages indicated in Classes A and B don't state the voltage the helmets protect wearers. Helmets also get tested for penetration and impact resistance from flames, water absorption, and blows to the top of wearers' heads.

Leg and Foot Protection

In any workplace, there's a high risk of foot injuries. These injuries primarily occur while employees perform their normal activities at the workplace. Leg and foot PPE protects against rolling or falling objects, molten metal, hot water and steam, wet slippery surfaces, and sharp objects. Steel-toed boots are the most common leg and foot PPE in industrial plants. Similar protective equipment includes leggings and footguards.

Overalls are a must-have in industrial plants, and they protect workers and other occupants from chemical hazards, flames, liquid spills, and other hazards. When working in tight spaces, overalls protect workers from bruises and similar injuries while ensuring comfort. Furthermore, most overalls come with pockets designed to help workers carry their tools safely and comfortably.

Face and Eye Protection

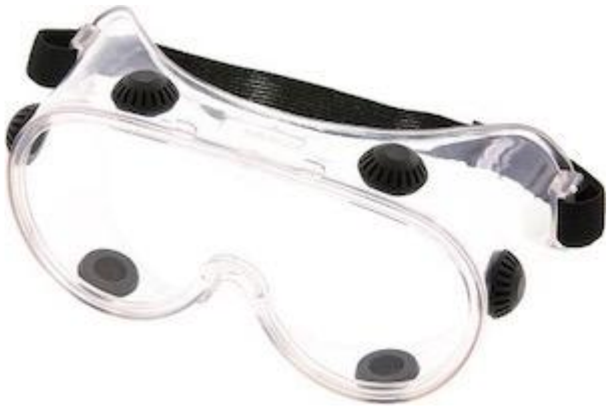


Fig 3.7 Face and Eye Protection Device

Employers should provide suitable eye protectors at workplaces with the potential for injury to the face or eyes from liquid chemicals, acids, molten metal, flying particles, vapors, and other hazardous materials. Eye and face PPE equipment should meet the following requirements:

- Provide adequate protection to the eyes and face
- Be comfortable when who under their designated conditions
- Fit without interfering with the wearer's movements and vision
- Easy to clean and repair
- Standard eye and face PPEs include safety glasses, chemical safety goggles, impact goggles, welding helmets, full-face respirators, and face shields.

Ear Protection

Continued exposure to high noise levels can cause hearing impairments and loss. Unfortunately, noise-induced hearing loss has no cure. Avoiding exposure is the only way to prevent hearing damage. In industrial settings, specifically designed ear protection PPE is required. Disposable earplugs are the most common ear protection PPE while earmuffs ensure a perfect seal around the ears.

Hand and Arm Protection

Hand and arm injuries commonly result from electric shock, burns, amputation, cuts, and chemical absorption. Most PPE offer protection from these hazards, including hand pads, sleeves, wristlets, and safety gloves.

PPE equipment should be selected according to the intended purpose. Likewise, each material should get thoroughly tested and rated against different chemical compounds. Thus, buyers should know what hazard they're protecting against to choose the most suitable PPE material. Rubber is the ideal material for hand gloves and sleeves due to its high-strength construction and insulating properties.

Respiratory Protection

In industrial settings, it's easy to breathe air contaminated with toxic fumes, smoke, sprays, vapors, gases, and dust. Even with the use of emergency controls to eliminate these dangerous substances from the air, respiratory protection PPEs can help avoid inhalation hazards.

Respiratory protection PPEs can either be air-purifying or atmosphere-supplying, and each of them provides a different protection level based on design. Thus, it's best to choose the appropriate respiratory protection PPE for the specific respiratory hazard.

Typical respiratory protectors include face masks, filtering facepiece respirators (FFRs), elastomeric full facial respirators, powered air-purifying respirators, and half-masks.

First Aid Kits

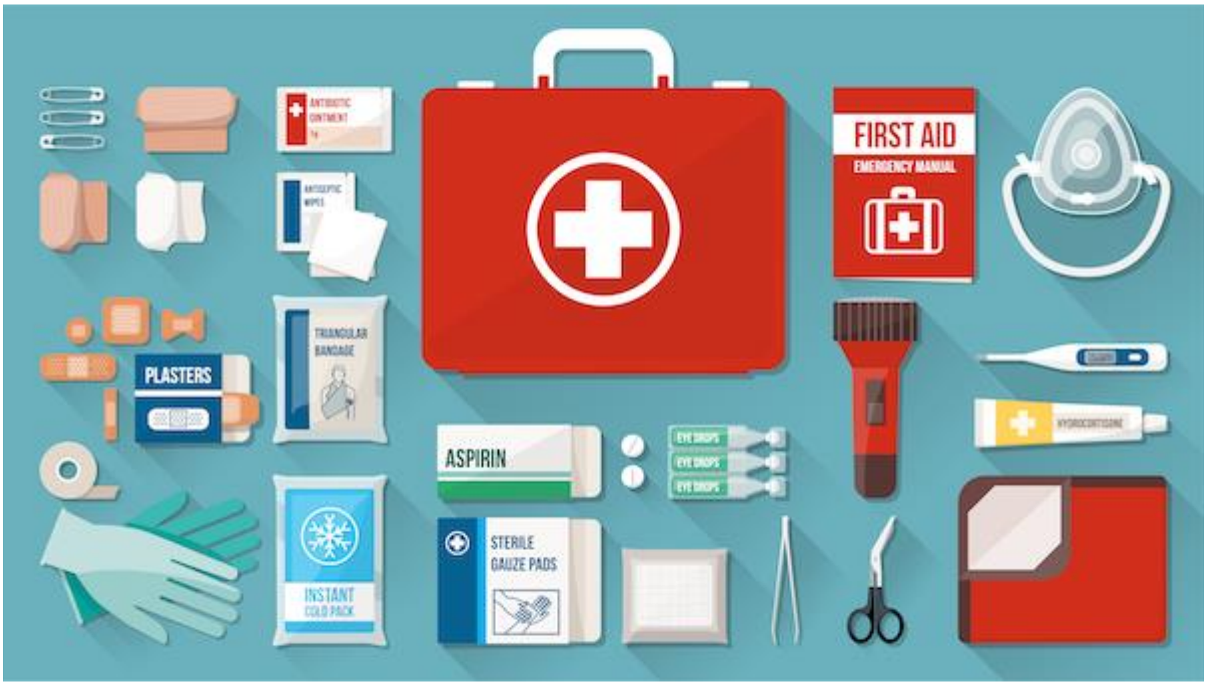


Fig 3.8 First Aid Kits

Scrapes, burns, cuts, and similar injuries are commonplace in industrial plants. Although a first aid kit isn't a PPE, having one close by can help you manage different types of damages. First aid kits are available for specific applications and work environments, such as electrical, construction, metalworking, or woodworking. Immediate treatment lowers the risk of minor injuries becoming severe. Hence, it's advisable to have a couple of well-stocked first aid kits at your workplace.

Eye protection

Blasting and spraying hood

First aid kits

Ear protection

Respiratory protection

3.9 The 4 Basic Types

However, even the strictest controls will not necessarily eliminate all the risks associated with most job tasks and this is where the need for PPE must be evaluated. A hazard assessment can help identify which specialized PPE will be required. There are numerous types of workplace safety equipment available depending on the hazard exposure and work conditions. The following are basic PPE that can help protect employees:

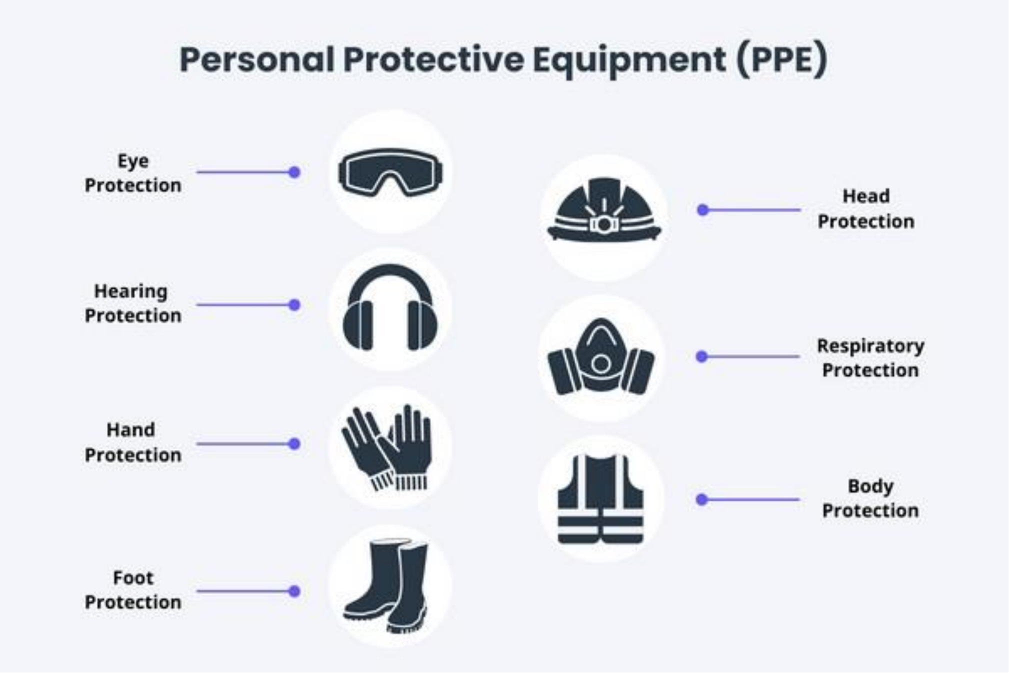


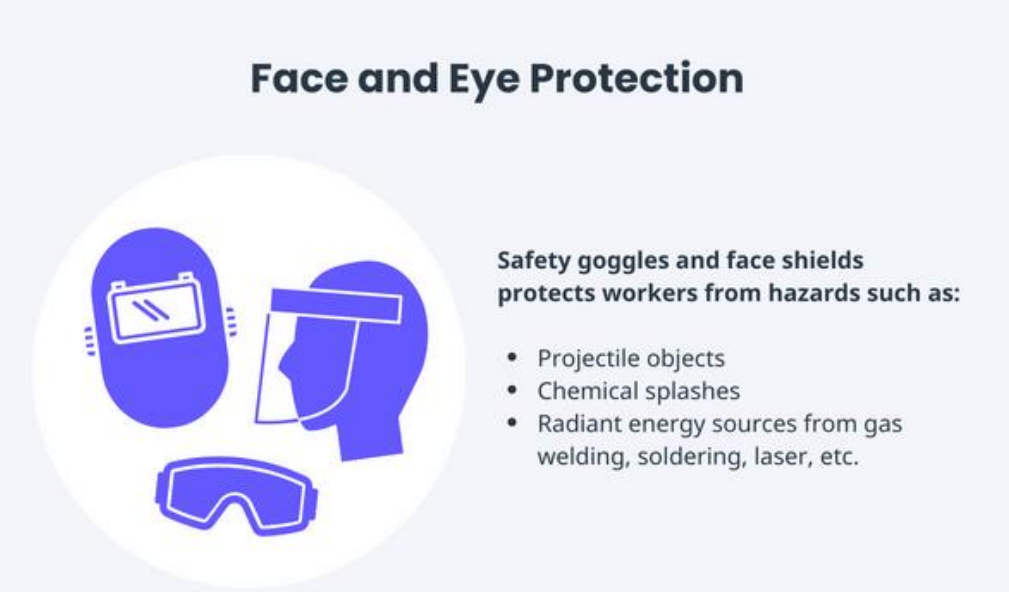
Fig 3.9 Personal Protective Equipments

Face and Eye Protection

PPE includes safety goggles and face shields and should be used for tasks that can cause eye damage or loss of vision, sprays of toxic liquids, splashes, and burns.

Safety Tips:

- Check if safety glasses comply with the ANSI Z87.1 eye protection standard.
- Ensure that there are no cracks or deformities on the lenses.
- Ensure the strap is in good working condition and is firmly sealed to the cheek and forehead.
- Clean and disinfect after use.



Face and Eye Protection

Safety goggles and face shields protects workers from hazards such as:

- Projectile objects
- Chemical splashes
- Radiant energy sources from gas welding, soldering, laser, etc.

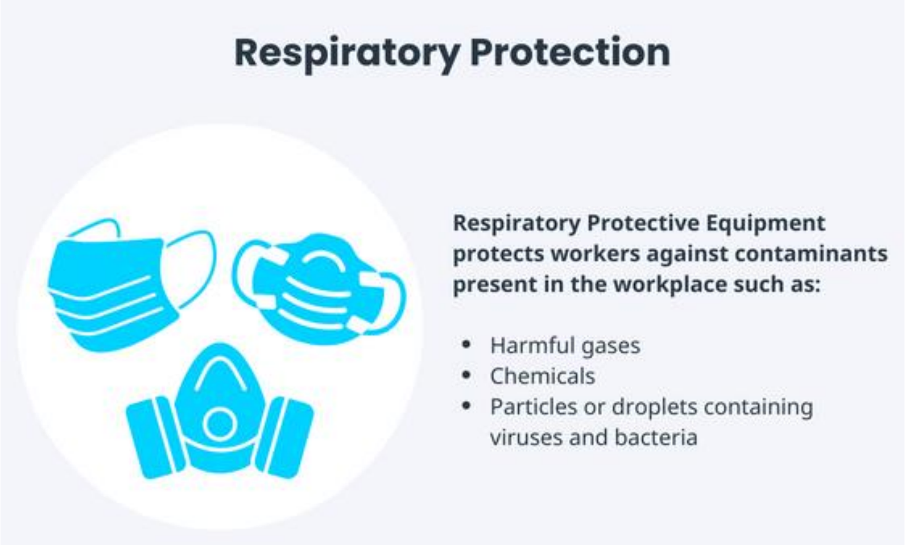
Fig 3.10 Face and Eye Protection

Respiratory Protection

PPE includes full-face respirators, self-contained breathing apparatus, gas masks, N95 respirators, and surgical masks are used for a task that can cause inhalation of harmful materials to enter the body. This includes harmful gas, chemicals, large-particle droplets, sprays, splashes, or splatter that may contain viruses and bacteria such as COVID-19, viral infections, and more.

Safety Tips:

- Ensure that the equipment is fit-tested and the employee has undergone proper training before wearing one.
- Carefully read the instructions to determine if it is designed to help protect against the hazards you may face.
- Change filters on half-mask or full-mask respirators frequently.
- Replace disposable respirators with every use.
- Surgical masks are not to be shared with anyone.
- Avoid touching the surgical mask after wearing it.
- Change surgical mask timely and should be disposed of after use.
- Replace the mask immediately if it is damaged or soiled.



Respiratory Protection

Respiratory Protective Equipment protects workers against contaminants present in the workplace such as:

- Harmful gases
- Chemicals
- Particles or droplets containing viruses and bacteria

Fig 3.11 Respiratory Protective Equipments

Skin and Body Protection

PPE includes the following categories to protect employees from physical hazards:

Head Protection

PPE includes hard hats and headgears and should be required for tasks that can cause any force or object falling to the head.

Safety Tips:

- Ensure that there are no dents or deformities on the shell and connections are tightened inside.
- Do not store in direct sunlight as extreme heat can cause damage.
- Choose appropriate cleaning agents as it can weaken the shells of hard hats and may eliminate electrical resistance.
- Always replace a hard hat if it was used for any kind of impact, even if the damage is unnoticeable.

Body Protection

PPE includes safety vests and suits that can be used for tasks that can cause body injuries from extreme temperatures, flames and sparks, toxic chemicals, insect bites and radiation.

Safety Tips:

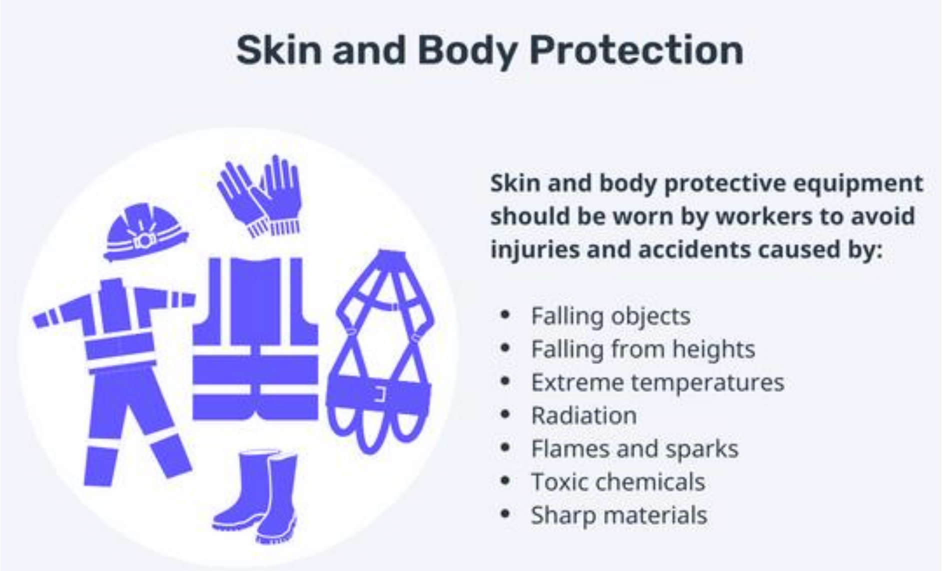
- Ensure that they are clean and free from cuts and burns.
- Always get a good fit to ensure full body protection.
- Ensure bodysuit is heat-resistant clothing when working with high-temperature hazards.

Hands Protection

PPE includes safety gloves and should be used for tasks that can cause hand and skin burns, absorption of harmful substances, cuts, fractures or amputations.

Safety Tips:

- ➢ Ensure hand protection fits perfectly with no spaces and is free from cuts, burns and chemical residue.
- ➢ Always replace them if any sign of contamination was observed.
- ➢ Use rubber gloves when working with heat and electricity to reduce the risk of burn or electrical shock.



Skin and Body Protection

Skin and body protective equipment should be worn by workers to avoid injuries and accidents caused by:

- Falling objects
- Falling from heights
- Extreme temperatures
- Radiation
- Flames and sparks
- Toxic chemicals
- Sharp materials

Fig 3.12 Skin and Body Protective Equipments

Foot Protection

PPE includes knee pads and safety boots and should be used for tasks that can cause serious foot and leg injuries from falling or rolling objects, hot substances, electrical hazards, and slippery surfaces.

Safety Tips:

- ➢ Ensure boots have slip-resistant soles that can protect against compression and impact.
- ➢ Ensure the sole plate is in good condition to prevent punctures.

Fall Protection

PPE includes safety harnesses and lanyards and should be strictly used for tasks that can cause falling from heights and serious injury or death.

Safety Tips:

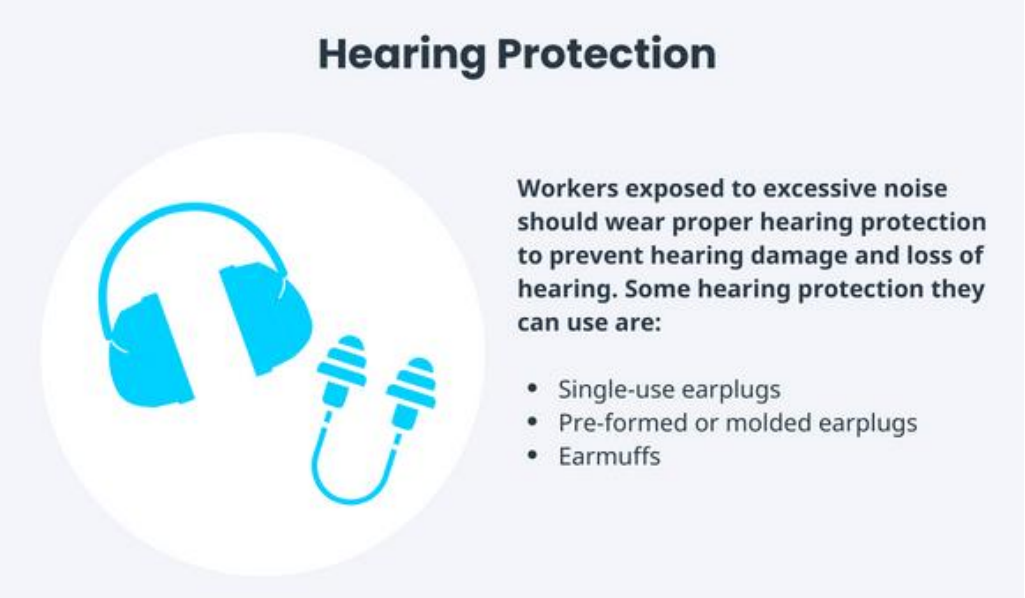
- Ensure that the straps are free from tears, deformities and burn marks.
- Check the buckles if connected securely and tightly.
- Dispose of the equipment if used after a falling incident.

Hearing Protection

PPE includes ear muffs and plugs and should be used for tasks that can cause hearing problems and loss of hearing.

Safety Tips:

- Ensure the equipment fit the ear canal perfectly.
- It is recommended to use formable earplugs to fit on different sizes of ear canals.
- Use protectors that reduce noise to an acceptable level to have a room for communication.
- Ensure earplugs are clean and in good condition.



Hearing Protection

Workers exposed to excessive noise should wear proper hearing protection to prevent hearing damage and loss of hearing. Some hearing protection they can use are:

- Single-use earplugs
- Pre-formed or molded earplugs
- Earmuffs

Fig 3.13 Hearing Protective Equipments

* * *

UNIT – 4

HAZARD ANALYSIS

UNIT – 4

SYSTEM SAFETY ANALYSIS

System safety analysis (SSA) is a field within safety engineering that uses a proactive approach to risk management. SSA looks ahead to system failure and anticipated human behavior and interaction with system process equipment.

The goal of SSA is to ensure safe working environments by proactively identifying risks, then eliminating or controlling the risk through engineering or behavioral methods. Engineering methods could include monitoring equipment to detect pressure increases or leaks. Behavioral methods could include detailed start up procedures for each piece of equipment in the system process. Now let's look at different steps involved in a system safety analysis.

4.1 System Safety Analysis Techniques

4.1.1 Fault Tree Analysis

Fault Tree Analysis (FTA) helps Alonzo identify potential causes of system failures before the failures actually occur. FTA uses statistical measures of failure rate, failure probability, and repair rate, often with both qualitative and quantitative risk assessment. This technique is mainly used in reliability and safety engineering within high-hazard areas, but is also useful during the design phase of systems for determining safety requirements.

Alonzo will use fault tree analysis to determine the probability of an oil spill at the factory where he works. The analysis compares the possibility of faulty valves with the possibility of short circuits within the system. This process allows Alonzo to be prepared for each circumstance based on probability of failure.

Fault tree analysis (**FTA**) is a type of failure analysis in which an undesired state of a system is examined. This analysis method is mainly used in safety engineering and reliability engineering to understand how systems can fail, to identify the best ways to reduce risk and to determine (or get a feeling for) event rates of a safety accident or a particular system level (functional) failure. FTA is used in the aerospace, nuclear power, chemical and process, pharmaceutical, petrochemical and other high-hazard industries; but is also used in fields as diverse as risk factor identification relating to social service system failure. FTA is also used in software engineering for debugging purposes and is closely related to cause-elimination technique used to detect bugs.

In aerospace, the more general term "system failure condition" is used for the "undesired state" / top event of the fault tree. These conditions are classified by the severity of their effects. The most severe conditions require the most extensive fault tree analysis. These system failure conditions and their classification are often previously determined in the functional hazard analysis.

USAGE

Fault tree analysis can be used to:

- understand the logic leading to the top event / undesired state.
- show compliance with the (input) system safety / reliability requirements.
- prioritize the contributors leading to the top event- creating the critical equipment/parts/events lists for different importance measures
- monitor and control the safety performance of the complex system (e.g., is a particular aircraft safe to fly when fuel valve *x* malfunctions? For how long is it allowed to fly with the valve malfunction?).
- minimize and optimize resources.
- assist in designing a system. The FTA can be used as a design tool that helps to create (output / lower level) requirements.
- function as a diagnostic tool to identify and correct causes of the top event. It can help with the creation of diagnostic manuals / processes.

HISTORY

Fault tree analysis (FTA) was originally developed in 1962 at Bell Laboratories by H.A. Watson, under a U.S. Air Force Ballistics Systems Division contract to evaluate the Minuteman I Intercontinental Ballistic Missile (ICBM) Launch Control System. The use of fault trees has since gained widespread support and is often used as a failure analysis tool by reliability experts. Following the first published use of FTA in the 1962 Minuteman I Launch Control Safety Study, Boeing and AVCO expanded use of FTA to the entire Minuteman II system in 1963–1964. FTA received extensive coverage at a 1965 System Safety Symposium in Seattle sponsored by Boeing and the University of Washington. Boeing began using FTA for civil aircraft design around 1966.

Subsequently, within the U.S. military, application of FTA for use with fuses was explored by Picatinny Arsenal in the 1960s and 1970s. In 1976 the U.S. Army Materiel Command incorporated FTA into an Engineering Design Handbook on Design for Reliability. The Reliability Analysis Center at Rome Laboratory and its successor organizations now with the Defense Technical Information Center (Reliability Information Analysis Center, and now Defense Systems Information Analysis Center) has published documents on FTA and reliability block diagrams since the 1960s. MIL-HDBK-338B provides a more recent reference

In 1970, the U.S. Federal Aviation Administration (FAA) published a change to 14 CFR 25.1309 airworthiness regulations for transport category aircraft in the Federal Register at 35 FR 5665 (1970-04-08). This change adopted failure probability criteria for aircraft systems and equipment and led to widespread use of FTA in civil aviation. In 1998, the FAA published Order 8040.4, establishing risk management policy including hazard analysis in a range of critical activities beyond aircraft certification, including air traffic control and modernization of the U.S. National Airspace System. This led to the publication of the FAA System Safety Handbook, which describes the use of FTA in various types of formal hazard analysis.

Early in the Apollo program the question was asked about the probability of successfully sending astronauts to the moon and returning them safely to Earth. A risk, or reliability, calculation of some sort was performed and the result was a mission success probability that was unacceptably low. This result discouraged NASA from further quantitative risk or reliability analysis until after the *Challenger* accident in 1986. Instead, NASA decided to rely on the use of failure modes and effects analysis (FMEA) and other qualitative methods for system safety assessments. After the *Challenger* accident, the importance of probabilistic risk assessment (PRA) and FTA in systems risk and reliability analysis was realized and its use at NASA has begun to grow and now FTA is considered as one of the most important system reliability and safety analysis techniques.

Within the nuclear power industry, the U.S. Nuclear Regulatory Commission began using PRA methods including FTA in 1975, and significantly expanded PRA research following the 1979 incident at Three Mile Island This eventually led to the 1981 publication of the NRC Fault Tree Handbook NUREG–0492, and mandatory use of PRA under the NRC's regulatory authority.

Following process industry disasters such as the 1984 Bhopal disaster and 1988 Piper Alpha explosion, in 1992 the United States Department of Labor Occupational Safety and Health Administration (OSHA) published in the Federal Register at 57 FR 6356 (1992-02-24) its Process Safety Management (PSM) standard in 19 CFR 1910.119. OSHA PSM recognizes FTA as an acceptable method for process hazard analysis (PHA).

Today FTA is widely used in system safety and reliability engineering, and in all major fields of engineering.

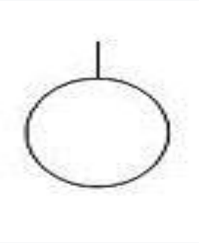
4.1.2 DRAWING A FAULT TREE ANALYSIS

Graphic symbols

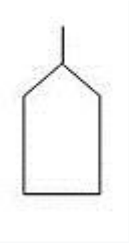
The basic symbols used in FTA are grouped as events, gates, and transfer symbols. Minor variations may be used in FTA software.

Event symbols (Algoritham Representaions)

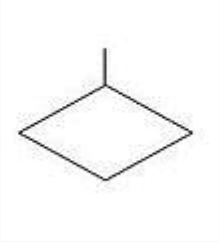
Event symbols are used for *primary events* and *intermediate events*. Primary events are not further developed on the fault tree. Intermediate events are found at the output of a gate. The event symbols are shown below:



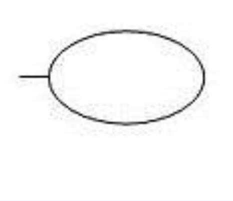
Basic event



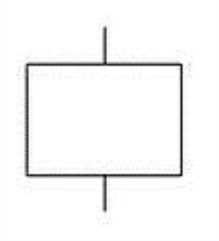
External event



Undeveloped event



Conditioning event



Intermediate event

The primary event symbols are typically used as follows:

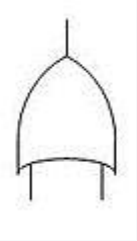
- **Basic event** - failure or error in a system component or element (example: switch stuck in open position)
- **External event** - normally expected to occur (not of itself a fault)
- **Undeveloped event** - an event about which insufficient information is available, or which is of no consequence
- **Conditioning event** - conditions that restrict or affect logic gates (example: mode of operation in effect)

An intermediate event gate can be used immediately above a primary event to provide more room to type the event description.

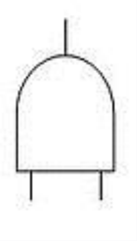
FTA is a top-to-bottom approach.

Gate symbols

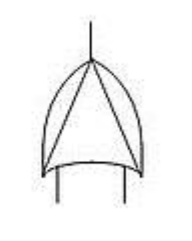
Gate symbols describe the relationship between input and output events. The symbols are derived from Boolean logic symbols:



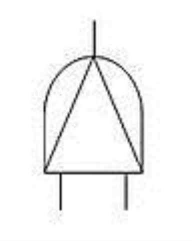
OR gate



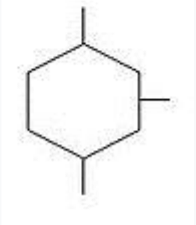
AND gate



Exclusive OR gate



Priority AND gate



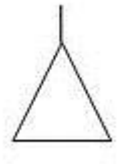
Inhibit gate

The gates work as follows:

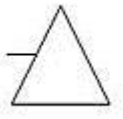
- **OR gate** - the output occurs if any input occurs.
- **AND gate** - the output occurs only if all inputs occur (inputs are independent from the source).
- **Exclusive OR gate** - the output occurs if exactly one input occurs.
- **Priority AND gate** - the output occurs if the inputs occur in a specific sequence specified by a conditioning event.
- **Inhibit gate** - the output occurs if the input occurs under an enabling condition specified by a conditioning event.

Transfer symbols

Transfer symbols are used to connect the inputs and outputs of related fault trees, such as the fault tree of a subsystem to its system. NASA prepared a complete document about FTA through practical incidents.



Transfer in



Transfer out

Traditional Fault Tree Event Symbols and their RBD Equivalents

Primary Event Block	Classic FTA Symbol	Description	RBD Equivalent
Basic Event	○	A basic initiating fault (or failure event).	Block
External Event (House Event)	⌂	An event that is normally expected to occur. In general, these events can be set to occur or not occur (i.e., they have a fixed probability of 0 or 1).	Block that cannot fail or that is in a failed state.
Undeveloped Event	◇	An event which is no further developed. It is a basic event that does not need further resolution.	Block
Conditioning Event	⬭	A specific condition or restriction that can apply to any gate.	Block: Placement of the block will vary depending on the gate applied to.

Fig 4.1 Table of Traditional Fault Tree Event Symbols

4.2 Failure Modes and Effect Analysis

Failure Modes and Effect Analysis (FMEA) uses a step-by-step approach to identify possible failures in a design or process. While mainly a qualitative assessment, certain instances exist where quantitative analysis is used. These special instances involve using a failure rate model to determine probability and severity of the hazard. FMEA is often used when a process is being assessed or redesigned, mainly in manufacturing industries.

Failure modes and effect Analysis analyzes potential failures using three criteria:

1. Occurrence (failure cause and frequency)
2. Severity (impact of the failure)
3. Detection (likelihood of failure detection)

Alonzo can use the FMEA approach when looking at the oil spill hazard at his workplace. The following is a diagram that shows the classification and risk assessment based on Alonzo's hazard risk.

4.2.1 Introduction to Failure Mode and Effects Analysis (FMEA)

There are numerous high-profile examples of product recalls resulting from poorly designed products and/or processes. These failures are debated in the public forum with manufacturers, service providers and suppliers being depicted as incapable of providing a safe product. Failure Mode and Effects Analysis, or FMEA, is a methodology aimed at allowing organizations to anticipate failure during the design stage by identifying all of the possible failures in a design or manufacturing process.

Developed in the 1950s, FMEA was one of the earliest structured reliability improvement methods. Today it is still a highly effective method of lowering the possibility of failure.

What is Failure Mode and Effects Analysis (FMEA)

Failure Mode and Effects Analysis (FMEA) is a structured approach to discovering potential failures that may exist within the design of a product or process.

Failure modes are the ways in which a process can fail. Effects are the ways that these failures can lead to waste, defects or harmful outcomes for the customer. Failure Mode and Effects Analysis is designed to identify, prioritize and limit these failure modes.

FMEA is not a substitute for good engineering. Rather, it enhances good engineering by applying the knowledge and experience of a Cross Functional Team (CFT) to review the design progress of a product or process by assessing its risk of failure.

There are two broad categories of FMEA, **Design FMEA (DFMEA)** and **Process FMEA (PFMEA)**.

Design FMEA

Design FMEA (DFMEA) explores the possibility of product malfunctions, reduced product life, and safety and regulatory concerns derived from:

- Material Properties
- Geometry
- Tolerances
- Interfaces with other components and/or systems
- Engineering Noise: environments, user profile, degradation, systems interactions

Process FMEA

Process FMEA (PFMEA) discovers failure that impacts product quality, reduced reliability of the process, customer dissatisfaction, and safety or environmental hazards derived from:

- Human Factors
- Methods followed while processing
- Materials used
- Machines utilized
- Measurement systems impact on acceptance
- Environment Factors on process performance
-

Why Perform Failure Mode and Effects Analysis (FMEA)

Historically, the sooner a failure is discovered, the less it will cost. If a failure is discovered late in product development or launch, the impact is exponentially more devastating.

FMEA is one of many tools used to discover failure at its earliest possible point in product or process design. Discovering a failure early in Product Development (PD) using FMEA provides the benefits of:

- Multiple choices for Mitigating the Risk
- Higher capability of Verification and Validation of changes
- Collaboration between design of the product and process
- Improved **Design for Manufacturing and Assembly (DFM/A)**
- Lower cost solutions
- Legacy, Tribal Knowledge, and Standard Work utilization

Ultimately, this methodology is effective at identifying and correcting process failures early on so that you can avoid the nasty consequences of poor performance.

When to Perform Failure Mode and Effects Analysis (FMEA)

There are several times at which it makes sense to perform a Failure Mode and Effects Analysis:

- When you are designing a new product, process or service
- When you are planning on performing an existing process in a different way
- When you have a quality improvement goal for a specific process
- When you need to understand and improve the failures of a process

In addition, it is advisable to perform an FMEA occasionally throughout the lifetime of a process. Quality and reliability must be consistently examined and improved for optimal results.

How to Perform Failure Mode and Effects Analysis (FMEA)

FMEA is performed in seven steps, with key activities at each step. The steps are separated to assure that only the appropriate team members for each step are required to be present. The FMEA approach used by Quality-One has been developed to avoid typical pitfalls which make the analysis slow and ineffective. The Quality-One Three Path Model allows for prioritization of activity and efficient use of team time.

There are Seven Steps to Developing an FMEA:

1. FMEA Pre-Work and Assemble the FMEA Team
2. Path 1 Development (Requirements through Severity Ranking)
3. Path 2 Development (Potential Causes and Prevention Controls through Occurrence Ranking)
4. Path 3 Development (Testing and Detection Controls through Detection Ranking)
5. Action Priority & Assignment
6. Actions Taken / Design Review
7. Re-ranking RPN & Closure

4.2.2 The Steps for conducting FMEA

1. FMEA Pre-Work and Assembly of the FMEA Team

Pre-work involves the collection and creation of key documents. FMEA works smoothly through the development phases when an investigation of past failures and preparatory documents is performed from its onset. Preparatory documents may include:

- Failure Mode Avoidance (FMA) Past Failure
- **Eight Disciplines of Problem Solving (8D)**
- Boundary/Block Diagram (For the DFMEA)
- Parameter Diagram (For the DFMEA)
- Process Flow Diagram (For the PFMEA)
- Characteristics Matrix (For the PFMEA)

A pre-work Checklist is recommended for an efficient FMEA event. Checklist items may include:

- Requirements to be included
- Design and / or Process Assumptions
- Preliminary Bill of Material / Components
- Known causes from surrogate products
- Potential causes from interfaces
- Potential causes from design choices
- Potential causes from noises and environments
- Family or Baseline FMEA (Historical FMEA)
- Past Test and Control Methods used on similar products

2. Path 1 Development- (Requirements through Severity Ranking)

Path 1 consists of inserting the functions, failure modes, effects of failure and Severity rankings. The pre-work documents assist in this task by taking information previously captured to populate the first few columns (depending on the worksheet selected) of the FMEA.

- Functions should be written in verb-noun context. Each function must have an associated measurable. Functions may include:
  - Wants, needs and desires translated
  - Specifications of a design
  - Government regulations
  - Program-specific requirements
  - Characteristics of product to be analyzed
  - Desired process outputs
- Failure Modes are written as anti-functions or anti-requirements in five potential ways:
  - Full function failure
  - Partial / degraded function failure
  - Intermittent function failure
  - Over function failure
  - Unintended function failure
- Effects are the results of failure, where each individual effect is given a Severity ranking. Actions are considered at this stage if the Severity is 9 or 10

        - Recommended Actions may be considered that impact the product or process design addressing Failure Modes on High Severity Rankings (Safety and Regulatory)

3. Path 2 Development – (Potential Causes and Prevention Controls through Occurrence Ranking)

Causes are selected from the design / process inputs or past failures and placed in the Cause column when applicable to a specific failure mode. The columns completed in Path 2 are:

- Potential Causes / Mechanisms of Failure
- Current Prevention Controls (i.e. standard work, previously successful designs, etc.)
- Occurrence Rankings for each cause
- Classification of Special Characteristics, if indicated
- Actions are developed to address high risk Severity and Occurrence combinations, defined in the Quality-One Criticality Matrix

4. Path 3 Development- (Testing and Detection Controls through Detection Ranking)

Path 3 Development involves the addition of Detection Controls that verify that the design meets requirements (for Design FMEA) or cause and/or failure mode, if undetected, may reach a customer (for Process FMEA).

- The columns completed in Path 3 are:
    - Detection Controls
    - Detection Ranking
- Actions are determined to improve the controls if they are insufficient to the Risks determined in Paths 1 and 2. Recommended Actions should address weakness in the testing and/or control strategy.
- Review and updates of the **Design Verification Plan and Report (DVP&R)** or **Control Plans** are also possible outcomes of Path 3.

5. Action Priority & Assignment

The Actions that were previously determined in Paths 1, 2 or 3 are assigned a Risk Priority Number (RPN) for action follow-up.

RPN is calculated by multiplying the Severity, Occurrence and Detection Rankings for each potential failure / effect, cause and control combination. Actions should not be determined based on an RPN threshold value. This is done commonly and is a practice that leads to poor team behavior. The columns completed are:

- Review Recommended Actions and assign RPN for additional follow-up
- Assign Actions to appropriate personnel
- Assign action due dates

6. Actions Taken / Design Review

FMEA Actions are closed when counter measures have been taken and are successful at reducing risk. The purpose of an FMEA is to discover and mitigate risk. FMEAs which do not find risk are considered to be weak and non-value added. Effort of the team did not produce improvement and therefore time was wasted in the analysis.

7. Re-Ranking RPN and Closure

After successful confirmation of Risk Mitigation Actions, the Core Team or Team Leader will re-rank the appropriate ranking value (Severity, Occurrence or Detection). The new rankings will be multiplied to attain the new RPN. The original RPN is compared to the revised RPN and the relative improvement to the design or process has been confirmed. Columns completed in Step 7:

- Re-ranked Severity
- Re-ranked Occurrence
- Re-ranked Detection
- Re-ranked RPN
- Generate new Actions, repeating Step 5, until risk has been mitigated
- Comparison of initial RPN and revised RPN

4.2.3 FMEA Document Analysis

Deciding when to take an action on the FMEA has historically been determined by RPN thresholds. Quality-One does not recommend the use of RPN thresholds for setting action targets. Such targets are believed to negatively change team behavior because teams select the lowest numbers to get below the threshold and not actual risk, requiring mitigation.

The analysis of an FMEA should include multiple level considerations, including:

- Severity of 9 / 10 or Safety and Regulatory alone (Failure Mode Actions)
- Criticality combinations for Severity and Occurrence (Cause Actions)
- Detection Controls (Test and Control Plan Actions)
- RPN Pareto

When completed, Actions move the risk from its current position in the Quality-One FMEA Criticality Matrix to a lower risk position.

4.3 HAZOP: Hazard and Operability

Hazard and Operability (HAZOP) is a systematic approach to determining potential problems that may be uncovered by reviewing the safety of designs and revisiting existing processes and operations in chemical, pharmaceutical, oil and gas, and nuclear industries.

A Hazard and Operability (HAZOP) study is a structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment, or prevent efficient operation. The HAZOP technique was initially developed to analyze chemical process systems, but has later been extended to other types of systems and also to complex operations and to software systems. A

HAZOP is a qualitative technique based on guide-words and is carried out by a multi-disciplinary team (HAZOP team) during a set of meetings.

4.3.1 OBJECTIVES OF HAZOP

Identify all deviations from the way a system is intended to function: their causes, and all the hazards and operability problems associated with these deviations. I Decide whether actions are required to control the hazards and/or the operability problems, and if so, identify the ways in which the problems can be solved. I Identify cases where a decision cannot be made immediately, and decide on what information or actions are required. I Ensure that actions decided are followed up. I Make operator aware of hazards and operability problems.

4.3.2 Types of HAZOP

Process HAZOP

- The HAZOP technique was originally developed to assess plants and process systems.

Human HAZOP

- A “family” of specialized HAZOPs. More focused on human errors than technical failures.

Procedure HAZOP

- Review of procedures or operational sequences Sometimes denoted SAFOP – SAFE Operation Study

Software HAZOP

- Identification of possible errors in the development of software

4.3.3 Purpose of HAZOP

HAZOP, also known as HAZOP study or HAZOP analysis, is a Process Hazard Analysis (PHA) method recognized in OSHA’s Process Safety Management (PSM) standard. It is a form of risk management to identify, evaluate, and control hazards and risks in complex processes. It involves highly hazardous chemicals that can cause significant injuries to workers and extensive damage to property and company reputation if not properly processed and handled. It helps the organization address:

- potential hazards in business operation;
- past incidents that had likelihood for catastrophic consequences;
- human-controlled factors; and
- consequences of failure of applied control measures including the range of the possible health and safety risks.

4.3.4 Importance of HAZOP for Multiple Industries

HAZOP is a risk assessment approach that has become the *de facto* industry standard. It is a highly structured method of analyzing any possible deviation that can happen in a complex plant including chemical, pharmaceutical, oil and gas, nuclear, and mining industries. It is a crucial task that helps multiple industries to:

- proactively catch hazards and help formulate risk mitigation early on during the planning or design stage of projects;
- realize risks during modification of current processes and see how deviations may occur from the design intent; and
- investigate how the plant or systems deviate from business goals that create a risk to personnel and operation.

4.3.5 HAZOP team leader Responsibilities:

- Define the scope for the analysis.
- Select HAZOP team members.
- Plan and prepare the study.
- Chair the HAZOP meetings
- Trigger the discussion using guide-words and parameters.
- Follow up progress according to schedule/agenda.
- Ensure completeness of the analysis.
- The team leader should be independent (i.e., no responsibility for the process and/or the performance of operations)

4.3.6 HAZOP team members

The basic team for a process plant may be:

- Project engineer
- Commissioning manager
- Process engineer
- Instrument/electrical engineer
- Safety engineer.

Depending on the actual process the team may be enhanced by:

- Operating team leader

- Maintenance engineer
- Suppliers representative
- Other specialists as appropriate

How to be a good HAZOP participant

Be active! Everybody’s contribution is important.
Be to the point. Avoid endless discussion of details.
Be critical in a positive way – not negative, but constructive.
Be responsible. She who knows should let the others know.

4.3.7 The Difference Between HAZOP, Risk Assessment, and HAZID

While risk assessments, HAZID, and HAZOP all aim to uncover safety risks in the workplace, there are differences.

HAZOP	HAZOP is potentially more time-consuming because it involves the rigorous review of newly designed or already established complex processes in order to uncover potential risks and deviations from the original design intent.
	HAZOP Template You can use this HAZOP template when in the process of identifying risks in design, procedure, or operation. Using this HAZOP template to conduct a HAZOP analysis of your processes, you can: Identify multiple scenarios or deviations to study; determine the critical safety and improvement points for your plans, systems, or processes; and immediately assign actions for urgent risks and notify the right person in real-time.
Risk Assessment	Risk assessment is the term used for the process of identifying risks, determining the severity of their impact, and coming up with controls to eliminate or mitigate the identified risks.

	Risk Assessment Template For identifying hazards and determining their risk rating, use this risk assessment template to record findings and provide some details on the most applicable control measures that can be used to mitigate or eliminate the risks discovered during risk assessments.
HAZID	Stands for Hazard Identification, HAZID is the process of proactively identifying hazards that can affect people, property, and the environment at the early stages of a project.
	Hazard Identification Template This hazard identification template is used to easily identify and document potential sources of injury or damage from performing a task in a specific work area. It helps to implement adequate corrective measures to ensure the health and safety of all employees.

4.3.8 Study Process (Steps Involved)

As HAZOP undertakes the careful review of complex processes involved in the handling and processing of chemicals and materials that can potentially harm workers and stakeholders if not properly contained and handled, it is important to follow the following steps:

1. Build a HAZOP team

Create a multidisciplinary HAZOP team composed of a team leader and members who can collaborate and provide different perspectives based on their fields of expertise at realizing sources of risks and possible deviations from design. An example of HAZOP team members would be design engineers, those who are very familiar with operations, and safety professionals.

2. Identify processes, P&ID, and HAZOP nodes

When beginning a HAZOP study, it is important to identify the processes in operations, be familiar with the process/piping and instrumentation diagram (P&ID), and be aware of all the nodes.

P&ID are drawings or diagrams that provide the visual representation of interconnected processes, equipment, and controls in the physical plant. HAZOP nodes are sections in the entire process where changes happen and they need to be reviewed along with Material Safety Data Sheets (MSDS) so that parameters can be defined and deviations are identified.

Safety Data Sheet Template

Use this SDS template when identifying chemicals and other materials' properties that can pose hazards to workers. Completed SDS in SafetyCulture (formerly iAuditor) can be easily retrieved during HAZOP reviews.

3. Define the parameters, determine deviations, and select guide words

Define parameters or safe operating limits during the review of nodes so that deviations can be determined and guide words are selected.

Examples of common HAZOP guide words:

- No or not
- More
- Less
- High
- Low

With the use of guide words, workplace hazards can be clearly identified as they are the deviations that go beyond acceptable parameters or safe operating limits.

4. Identify controls and establish safety monitoring

With hazards identified, the corresponding hazard mitigation or elimination strategies should be applied to maintain the safety of the workplace. With ongoing processes and production, monitoring should also be established to ensure that safeguards are still effective and safety procedures are being followed.

Monitoring is only effective when it is actually conducted regularly. With SafetyCulture as mobile safety monitoring software, you can ensure that safety checks and audits are conducted regularly through scheduled inspections and automated notifications. Administrators can schedule and assign inspections and be made aware if inspections are indeed being done on time and on a regular basis. Register here for free.

Another safeguard is to automate safety monitoring through sensors. Sensors can trigger automated notifications for intended personnel whenever safety parameters are exceeded in real-time.

5. Communicate HAZOP results and improve processes

The result of the HAZOP analysis can be used to help elevate safety within the plant and improvements in safety practices and processes should be communicated to as appropriate to employees e.g. occupational safety, chemical safety and hygiene safety processes.

An effective approach to safety training or program will also help hasten the implementation of changes and reinforce safety across the board.

HAZOP is rigorous and can take a lot of time and resources to complete, but by following HAZOP steps and using tools that can help hasten the process without compromising the quality of the process and its result, HAZOP can be effectively conducted and completed sooner and the workplace can be made safer and more efficient.

4.4 Phases of Analysis

A HAZOP analysis is conducted by a suitably experienced multi-disciplinary team to thoroughly examine a planned or existing process. It helps identify and evaluate health hazards that may endanger people or hinder efficient operation of the business. A HAZOP analysis is executed in four phases, as follows:

Definition Phase

The definition phase typically begins with the preliminary selection of risk assessment team members. After building the team, they must clearly define their responsibilities and identify their objective and assessment scope including study boundaries, key interfaces, and assumptions.

Preparation Phase

During the preparation phase, the team should identify and locate supporting data and information to plan the study. They have to prepare the schedule, timelines, and template format for recording study outputs.

Examination Phase

The examination phase begins with the identification of all elements such as parts or steps of the system or process to be examined. The team has to classify deviation using guide words on each element and identify consequences and causes of problems. They have to establish protection, detection process, and supporting mechanisms.

◆

UNIT – 5

SAFETY REGULATIONS

UNIT – 5

SAFETY REGULATIONS

5.1 EXPLOSIONS

Dangerous substances are any substances used or present at work that could, if not properly controlled, cause harm to people as a result of a fire, explosion or similar incident, such as an uncontrolled chemical reaction. They can be found in nearly all workplaces and include such things as solvents, paints, varnishes, flammable gases, liquefied petroleum gas (LPG), dusts from machining and sanding operations, and dusts from foodstuffs. Dangerous substances do not include all materials that can catch fire in the workplace. However, some materials that can cause the rapid escalation of a fire if handled in a certain way are also classed as dangerous substances under DSEAR (eg cellular plastic foams.

The risk assessment under Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) includes five steps.

Step 1 Identify the fire and explosion hazards and hazards from similar energetic events.

This should be an identification and careful examination of:

- The dangerous substances present, including those that may be formed in the workplace;
- The potential ignition sources of the dangerous substances;
- The work activities involving the dangerous substances;
- The possible formation and extent of explosive atmospheres;
- The scale of the anticipated effects from the fire, explosion or similar energetic event.

Step 2 Decide who might be harmed and how

Identify the people at risk from the fire, explosion hazards or similar energetic event involving the dangerous substance.

Step 3 Evaluate the risks and decide on precautions

You should determine whether the measures taken are adequate to eliminate or reduce the risks from dangerous substances, so far as is reasonably practicable.

This should take account of such things as:

- The possible substitution of the dangerous substance by one that is nonhazardous, or one that is less hazardous;

- The control measures to prevent a fire, explosion or similar energetic incident from occurring;
- The mitigation measures to limit the scale and magnitude of the incident should it occur.

Step 4 Record your findings and implement control measures

If you employ five or more employees, you should record the significant findings of your risk assessment. This should include the location and extent of explosive atmospheres and their classification in terms of zones.

The risk assessment should also help you decide on:

The information, instruction and training you give to your employees. This should be sufficient for them to safeguard themselves and others from the risks presented by the dangerous substances;

The arrangements to deal with accidents, incidents and emergencies, including involvement of the emergency services.

Step 5 Review your risk assessment and update if necessary.

If you introduce significant changes to your workplace, such as changing the dangerous substances present or their quantities, or changing the work equipment or processes, you should review your risk assessment.

Similarly, you should do this in the event of an incident, including a near miss – for example a release of a dangerous substance without ignition – to determine if the measures you have in place are sufficient.

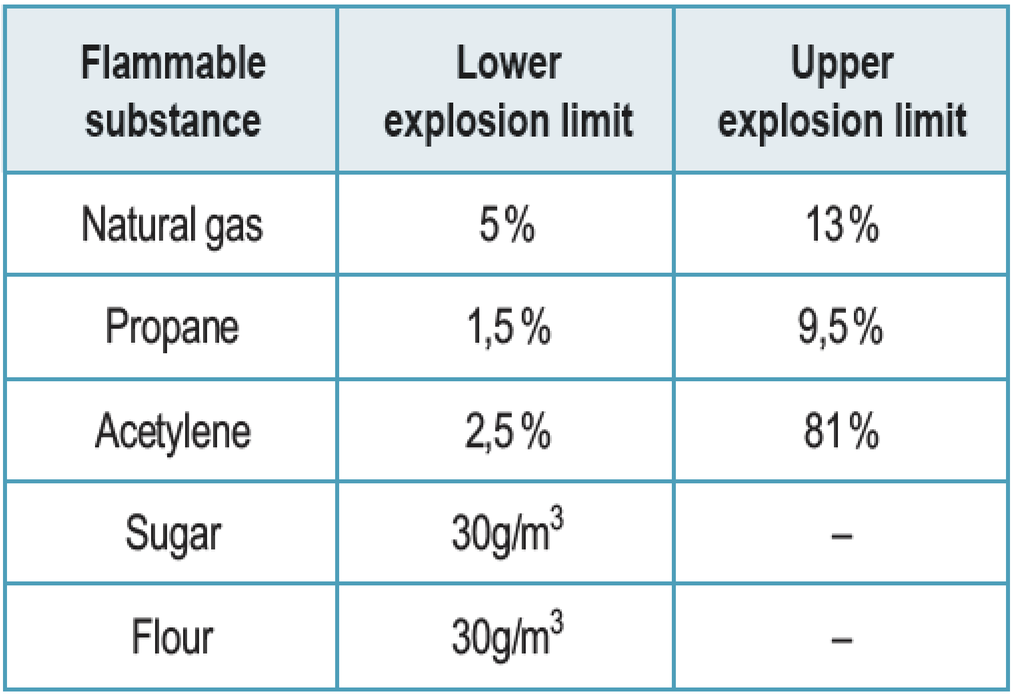
Prioritize your control measures as follows:

- Reduce the quantity of dangerous substances to a minimum;
- Avoid or minimise releases of dangerous substances;
- Control releases of dangerous substances at source;
- Prevent the formation of an explosive atmosphere, including by ventilation;
- Collect, contain and remove any releases to a safe place;
- Avoid ignition sources;
- Avoid adverse conditions (such as exceeding pressure/temperature limits) that could lead to danger; Keep incompatible substances apart.

Elements of an explosion

- When a flammable gas escapes, or a flammable liquid or vapour leaks, or a flammable dust disperses in the working environment.
- When the flammable material is mixed with air, an explosive atmosphere can be formed.
- If the concentration of material in the mixture is within the explosion limits (Lower and Upper)
- Lower explosion limit (LEL) – is the minimum
- concentration of flammable gas, flammable liquid vapour or dust with air, where an explosion can occur.

- Upper explosion limit (UEL) – is the maximum concentration of flammable gas, flammable liquid vapour or dust with air where an explosion can occur.



Flammable substance	Lower explosion limit	Upper explosion limit
Natural gas	5 %	13 %
Propane	1,5 %	9,5 %
Acetylene	2,5 %	81 %
Sugar	30g/m^3	–
Flour	30g/m^3	–

Fig5.1 Table of Explosive Limits of Various Flammable Substance

- Although an explosion happens at the blink of an eye, there are Several phases which happen at that instant: the original shock wave blast of the explosion; the flying fragments of the exploding container; and, depending on the pressure of the blast, parts of walls, roof, floors, doors, windows and ceilings could collapse.
- Also, the generated heat may cause secondary fires, burns and secondary structural collapse/damage.
- Moreover, shock waves may severely damage gas, water, electric and sewer pipes. The effects of an explosion are severe and the consequences in human lives and destruction of property dramatic.
- Typical ignition sources are hot surfaces, flames and hot gases, mechanically generated sparks (while grinding or cutting), electrical sparks, static electricity, etc.
- Other ignition sources are: lightning, electromagnetic fields, chemical reactions, etc.
- Details on the various types of ignition sources can be found in the European standard.

5.1.1 Additional requirements where explosive atmospheres can occur/Hazardous zone classification.

- The correct implementation of control measures aims to prevent the formation of potentially explosive atmospheres, or limit their extent. However, due to the way dangerous substances are stored, handled and used, you cannot fully avoid the risk of potentially explosive atmospheres occurring.

- The areas where hazardous explosive atmospheres may occur should be identified and classified into zones, based on their likelihood and persistence. This is known as Hazardous Area Classification.

  The zone classifications are:

  Zone 0 (Zone 20) That part of a hazardous area in which an explosive atmosphere is continuously present, or present for long periods, or frequently.

  Zone 1 (Zone 21) That part of a hazardous area in which an explosive atmosphere is likely to occur occasionally in normal operation.

  Zone 2 (Zone 22) That part of a hazardous area in which an explosive atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

  Zones 0, 1 and 2 are used for explosive atmospheres formed of flammable gases, vapours or mists. Zones 20, 21 and 22 are used for explosive atmospheres formed of combustible dusts.

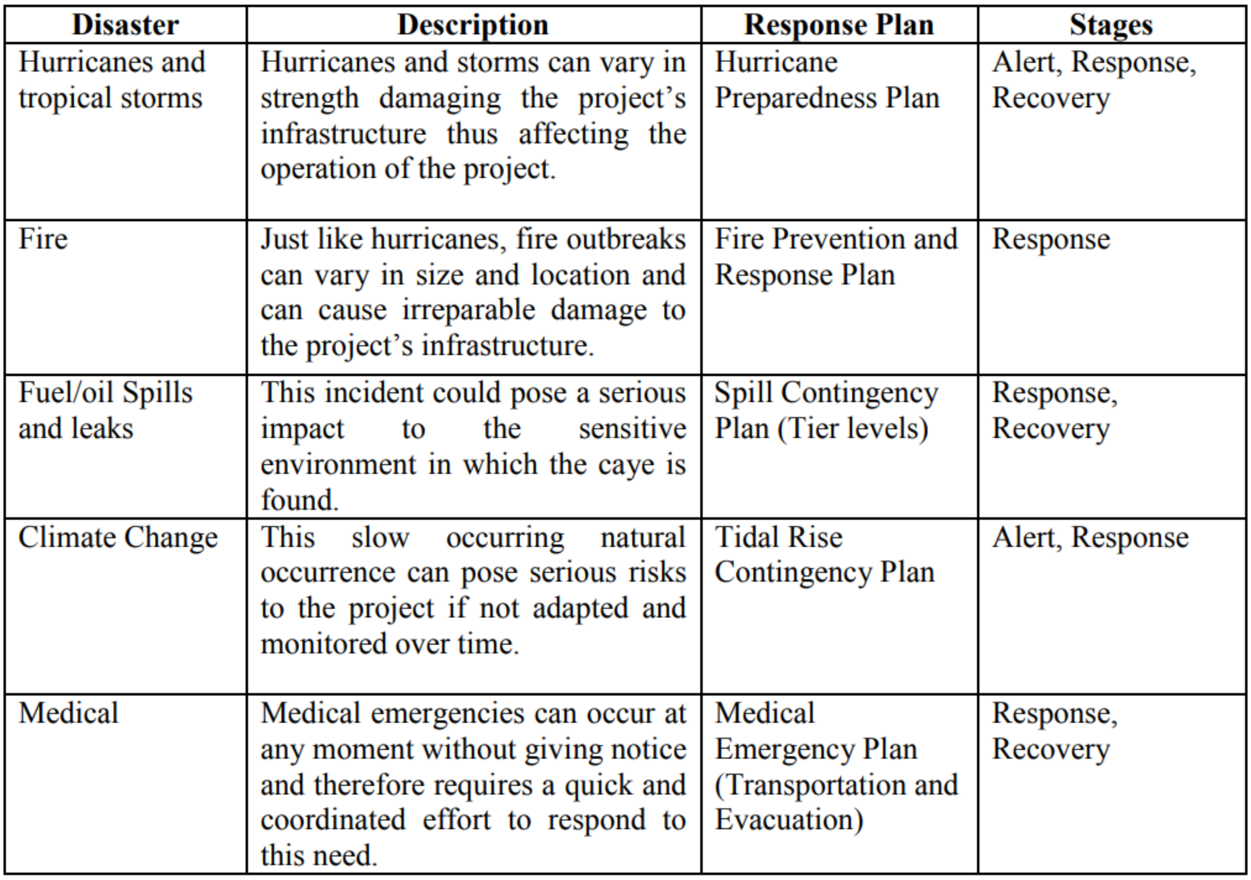
5.2 DISASTER MANAGEMENT

5.2.1 Disaster Classification

Disaster Management (or Emergency Management) is the discipline of dealing with and avoiding risks. It is a discipline that involves preparing, supporting and rebuilding when natural or human made disasters occur. The actions (efforts to avoid or ameliorate the impact) taken depends in part on the perceptions of the risk. In any event, an effective emergency management system will rely on the emergency plans available.

Considering the possibilities of such an occurrence, the project proponent plans to develop and implement a Disaster Management Plan aimed at identifying the different potential disasters that could impact the development. This plan will focus on five potential types of disasters that can arise from various sources and affect the operation and livelihood of the project in some form or fashion. Table 8.1 outlines some of the more likely disasters that could occur on site.

Summary of the Disaster Preparedness Plans for False Caye



Disaster	Description	Response Plan	Stages
Hurricanes and tropical storms	Hurricanes and storms can vary in strength damaging the project's infrastructure thus affecting the operation of the project.	Hurricane Preparedness Plan	Alert, Response, Recovery
Fire	Just like hurricanes, fire outbreaks can vary in size and location and can cause irreparable damage to the project's infrastructure.	Fire Prevention and Response Plan	Response
Fuel/oil Spills and leaks	This incident could pose a serious impact to the sensitive environment in which the caye is found.	Spill Contingency Plan (Tier levels)	Response, Recovery
Climate Change	This slow occurring natural occurrence can pose serious risks to the project if not adapted and monitored over time.	Tidal Rise Contingency Plan	Alert, Response
Medical	Medical emergencies can occur at any moment without giving notice and therefore requires a quick and coordinated effort to respond to this need.	Medical Emergency Plan (Transportation and Evacuation)	Response, Recovery

Fig 5.2 Disaster Preparedness Plans

5.2.2 Disaster Management Structure

The act of managing natural or man made disasters will require a team effort or more aptly a committee approach. With this, the management of the proposed development will formulate an Emergency Committee to address any of the aforementioned disasters in a quick, responsible and safe manner. This committee will be charged with the task of electing an Emergency Coordinator and his/her subordinate, who shall direct and execute all the activities outlined by the response plans. The emergency committee must conduct periodic meetings to address important issues concerning the disaster management plans. Such important issues should be the objectives of the committee, their roles and responsibilities, updates, training, drills as well as their terms of reference (TOR) which they will abide by. The Emergency Committee will also decide on the election policies for coordinators

5.2.3 Hurricane Preparedness Plan (Evacuation Plan)

The hurricane preparedness plan will involve an alert, response and recovery stage to deal with any natural disaster involving hurricanes, storms or tropical depressions. This is the most common natural phenomenon occurring in Belize and the only one that would require a full scale evacuation. Belize lies within the hurricane belt, and is vulnerable to high wind and storm surge. During the past 100 years, Belize has been hit several times by major hurricanes. Belize has been hit 40 times by storms ranging from tropical depressions to hurricanes (Usher, 2000).

The return period for storms since 1870 is three (3) years, and the vulnerability increases from North to South (Usher 2000). The hurricane season in Belize commences officially on June 1st and ends on November 30th . As part of its overall Management Plan, the EIA has also considered the issue of safety needs resulting from potential threats other than hurricanes. The Hurricane Preparedness Plan (HPP) is aimed at making reasonable preparations should the project be threatened by an imminent Tropical Depression or Hurricane strike. This is to enable the developers to protect their employees and assets, and also to ensure that the project is able to continue to function after the hurricane has passed.

For this plan to be effective the staff is required to review the plan every year prior to the beginning of the Hurricane Season: There will also be simulation exercises in relation to various elements of the plan.

Purpose of Plan

The purpose of this hurricane preparedness plan is to:

(i) Establish the coordinating mechanisms necessary to prepare and implement measures to safeguard property and lives of all concerned during the threat of a storm or hurricane.

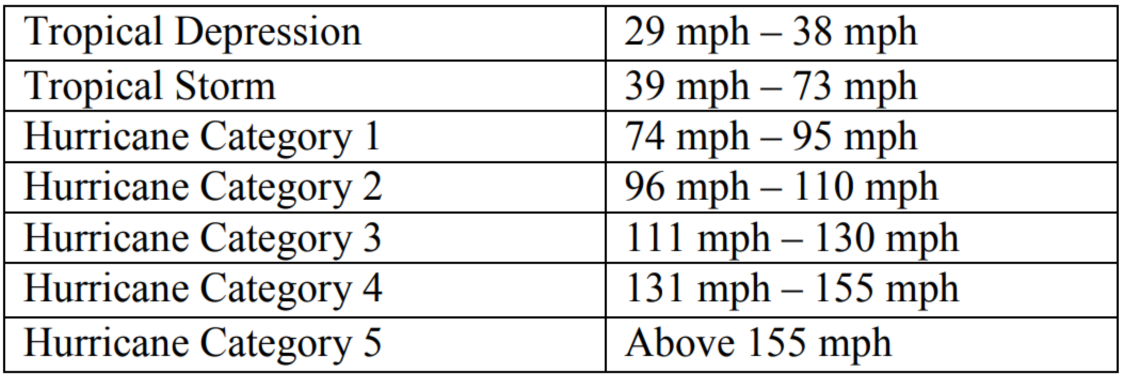
(ii) Increase awareness to management and others (boaters, guests etc.) of the need for hurricane preparedness,

The basic overall responsibilities of the management is to ensure that the coordinating mechanism that will ensure maximum safety of property or lives during an incoming storm, is put in place, and to make sure the developer or residents/guests are familiar with the mechanism.

Information System

The “official alert” system for a storm or hurricane entails the coordination between management, the National Emergency Management Organization (NEMO) and the Belize National Meteorological Service (NMS). The emergency coordinator will therefore activate the required hurricane plan.

The proposed project will follow the official alert and hurricane categories profile put in place by NEMO. Such categories along with the wind speeds are illustrated in the following:



Tropical Depression	29 mph – 38 mph
Tropical Storm	39 mph – 73 mph
Hurricane Category 1	74 mph – 95 mph
Hurricane Category 2	96 mph – 110 mph
Hurricane Category 3	111 mph – 130 mph
Hurricane Category 4	131 mph – 155 mph
Hurricane Category 5	Above 155 mph

False Caye will adopt the official Warning Flag System as follows:

Flags	Phases
One Red Flag	Preliminary Alert Phase (Storm/Hurricane Watch)
One Red flag with Black Center	RED I Phase (storm or hurricane watch)
Two Red Flags with Black Centers	RED II (Warning Phase)
One Green Flag	Green Phase (ALL CLEAR)

5.3 Implementation Plan during Threats

Actions to be Taken:

(i) The Emergency Committee should be prepared to convene and take action if the Belize Weather Bureau issues a warning.
(ii) Stay informed by radio and television of the storm progress.
(iii)Obtain hurricane tracking chart for Committee members and project management,
(iv)Obtain the contact number etc. from the Management, including guests with marine vessels, and inform vessel owners of the alert phase,
(v) Ensure that contact is made with all guests and captains of vessels, whether by direct or indirect means, to alert them of the phase and to make initial contact.
(vi)Prepare a checklist (electronically) of items required in the event of a strike.
(vii) The Emergency Coordinator will identify and categorize items or equipment to be removed as follows: list of equipment to stay, and list of those to be removed to designated site.
(viii) Prepare a tentative list of all the guests and management staff on the island.

5.3.1 Fire Prevention and Response Plan

The fire prevention and response plan will focus on the possibility of a fire and any fire outbreak, whether large or small, that might occur. It is therefore important to consider its likelihood and with this in mind, the development will develop a response plan aimed at addressing the awareness and the mechanism necessary for its response.

Presently, there is no fire service provided for the Placencia Peninsula. Therefore proposed development will therefore create its own service via the Emergency Committee in the form of engineering controls (fire protection equipment and building design) and the fire prevention plan.

Fire Protection Equipment/Systems

All the hotel and villa units along with other buildings on the property will be protected from fire in one form or another. False Caye will install protection systems to protect lives and property which are summarized below:

1) Fire alarm detection and notification systems.

Smoke detectors: The project will install fire detection equipment in the form of smoke detectors in each of the units and in the building hallways and walkways. The smoke detectors will activate the smoke alarm possibly signaling a fire or of something burning.

Manually activated pull station: The hotel and villa buildings will have a manually activated pull station in the event that someone sees a fire. It is essential that both guests, residents and staff are aware of these warning devices and their potential use in detecting fires.

2) Fire Suppression Systems.

Hydrants: Fire hydrants will be used on the project as a means of fighting fire. These hydrants will be spaced out according to each sewer zone. In other words, the four project sewer zones will have their own hydrant loop, and each sewer zone will be connected to each other via valves. Water for these hydrants will be gotten either from the recycled wastewater in each sewer zone or from the sea. Pumps at each sewer zone and at the service pier will be used to pressurize the fire hydrant loops. Flexible water hoses will be coupled to the hydrants and used to extinguish the fire.

Fire Extinguishers: False Caye will install multi-purpose dry chemical (Class ABC) fire extinguishers. Dry chemical extinguishers will range in sizes of 5 lbs to 10 lbs and will be installed in the hallways and walkways of the hotel and villa units. These will also be installed at key areas such as, containment walls, generators, electrical panels, maintenance areas, etc.

Fire Prevention

Fire prevention is an important aspect in precluding its occurrence. While water is plentiful at the project site, its immediate availability may not be possible. Measures designed to prevent and control fires include:

I. Use of fire retardant material - The use of nonflammable building material will be encouraged within the project. For example the use of sheet roofing instead of shingles will be encouraged and the use of fire rated doors, fire resistant windows and barriers.

II. Qualified personnel to install electrical system - Only certified Electricians will be allowed to carry out any electrical work on the premises. Each building, after completion should be approved by the Belize Electricity Limited.

III. Building Codes - The project will call for the construction of condos, cabañas and other buildings, with heights above (1) one and possibly (2) two stories high. A set of building codes will be developed by the engineers of the project, in order to ensure adequate construction of buildings. The engineering standards will also include provisions for adequate and safe wiring; plumbing, heating, and cooling systems are also in conformity with acceptable building codes.

Fire Response

Fires first start small and then grow large as time progresses and if there is enough fuel, oxygen and heat for the fire. Actions to be taken:

(i) Sound the alarm
ii) Use an extinguishing media preferably a fire extinguisher to fight the fire.
(iii)Do not fight a large fire with a fire extinguisher.
(iv)Check to see that the fire is completely extinguished.
(v) Inspect the fire area and assess for damages.
(vi)Close off the area for safety purposes.

At some point, the Emergency Coordinator needs to be notified of the situation. A report of the incident should be submitted to the Emergency Committee for assessment.

5.4 MITIGATION

Basic design of the Sugar & Cogeneration plant

While designing the plant, ensure maximum plant load factors. The plant cycle should be optimized to give the best efficiency. The success of the sugar & cogeneration plant depends on this "basic design". Plant layout is a part of the basic design and is very important from the point of view of operability and maintainability of the plant. The plant and equipment should be so laid out that there is optimum routing of piping, cables and conveyors. New boilers will be designed as per IS standard. Pilot lights will be provided on electrical panel boards. KDGDBLSSKL will provide hand operable firefighting cylinder at strategic location viz. power house, control panel room, PRDS section etc. The switchyard layout should be such that the transmission lines could be laid without difficulty and hindrance.

Steam generating System

Some fine tuning is required in the areas of excess air control and un-burnt carbon loss control. Feed water quality control is an area needing attention and this is separately dealt in the detailed project report (technical report).

Turbo generator System

Problems in maintaining the steam purity in the boilers affect the turbine with deposits on the blades. The major contaminant is silica that gets carried over as vapor as the operating pressure of the boiler increases. There could be some problems of vibration and failure of bearings. These could be due to-initial problems in the lube oil system, and these could be resolved by having proper pre-commissioning checks. Another problem observed usually in some industries is of exhaust hood spray falling on the blades and causing vibration. This is mainly due to a misdirected spray nozzle in the exhaust hood. Proper designing will resolve such problems.

Bagasse Handling

During the cane crushing season, the plant receives bagasse directly from the mill, and the surplus bagasse is taken to the yard. The bagasse thus saved will be used for the off-season operation of the cogeneration plant, or could be used to run the cogeneration plant on the cleaning days or when the mill is not running due to some other reasons. Under such circumstances, back feeding of the bagasse from the yard to the boiler has been provided.

Milling Section

Milling section, where the juice is extracted from the cane, is the most important section of sugar mill. This is where the bagasse is prepared as a fuel, and the moisture in the bagasse controlled to a value of around 50%. If there are problems with this section, the moisture content in the bagasse could go high and the bagasse will not be prepared well for handling and combustion. Other points related to milling section are the use of optimum imbibition and the use of electric or hydraulic drives for the mills.

Electrical Systems

As far as the technology for the cogeneration plant and design of the electrical systems is well established. All the electrical equipment required for the sugar & cogeneration plant, as well as its grid paralleling are available indigenously. The only problem faced by the cogeneration plants is the stability of the grid. There are baseless fears in the minds of the plant operators with regard to the ability of the cogeneration plant to cope up with the tripping of the grid. If the protections are properly chosen and the equipments are properly specified, there is no such probability.

Controls & Instrumentation

Being the most important subject from the point of view of operation and maintenance of the sugar & cogeneration plant, this subject deserves a lot of attention. Distributed Control System (DCS) is the order of the day. The technology for the planning and designing the complete controls & instrumentation system for the cogeneration plants is available, but what is required is to create awareness among sugar plant people about the importance of instrumentation in the operation and maintenance of the sugar & cogeneration plant.

5.5 CATASTROPHE CONTROL

This is a strong word for terrible, harmful, devastating things. Tornadoes, hurricanes, earthquakes, and tsunamis are catastrophic weather events. A depression is catastrophic for the economy. In sports, if the star player is injured, that's catastrophic for the team. If a parent dies, that's catastrophic for a family. Scientists worry that climate change will have a catastrophic effect on the planet.

Catastrophic events, such as wildland fires, flooding, and droughts, can also alter water quality in lakes and reservoirs in ways that affect urban water use. These events alter both the hydrology and transport of chemicals in watersheds, often resulting in large pulses of water, nutrients, sediments, and other chemicals.

For property and casualty insurers, catastrophes are infrequent events that cause severe loss, injury or property damage to a large population of exposures
While the term is most often associated with natural events (e.g., earthquakes, floods or hurricanes), it can also be used when there is concentrated or widespread damage from man-made disasters (e.g., fires, explosion, pollution or nuclear fallout).

- Whether losses arising out of an event are

- defined as a catastrophe depends on the size of the loss to the company or to the entire industry.
- Property Claim Services (PCS), a unit of the Insurance Services Office, Inc., analyzes catastrophes based on their impact on the industry as a whole.
- There are two type of Exposures
  - **Non-catastrophe Exposures**
  - **catastrophe Exposures**

Non-catastrophe Exposures

It is the nature of insurance, however, that prices must be set before coverage is sold and losses have occurred

Future insurance losses must be estimated.

In statistical terms two conditions are very desirable:

predictable frequency of claims over time
each exposure experiences loss independently of other exposures

Catastrophe Exposures

Catastrophes are infrequent, producing no losses in most years, and large losses in a few years, a clear violation of the first condition.

The second condition for non catastrophe exposures was independence.

Catastrophes cause loss to many exposures at once. Significant or high correlation among exposures is a key feature of catastrophe risk

- The five steps used by insurers to address catastrophe
  - Identifying catastrophe risk appetite
  - Measuring catastrophe exposure
  - Pricing for catastrophe exposure
  - Controlling catastrophe exposure
  - Evaluating ability to pay catastrophe losses

5.6 HAZARD CONTROL

- A hazard control program consists of all steps necessary to protect workers from exposure to a substance or system
- The training and the procedures required to monitor worker exposure and their health to hazards such as chemicals
- The materials or substance, or other types of hazards such as noise and vibration
-

A written workplace hazard control program should outline which methods are being used to control the exposure and how these controls will be monitored for effectiveness.

Choosing a control method may involve

- Evaluating and selecting temporary and permanent controls.
- Implementing temporary measures until permanent (engineering) controls can be put in place.
- Implementing permanent controls when reasonably practicable

Fig 5.3 Safe and Unsafe Zone comparision

The main ways to control a hazard include

- Elimination (including substitution)
- Engineering Controls
- Administrative Controls
- Personal Protective Equipment

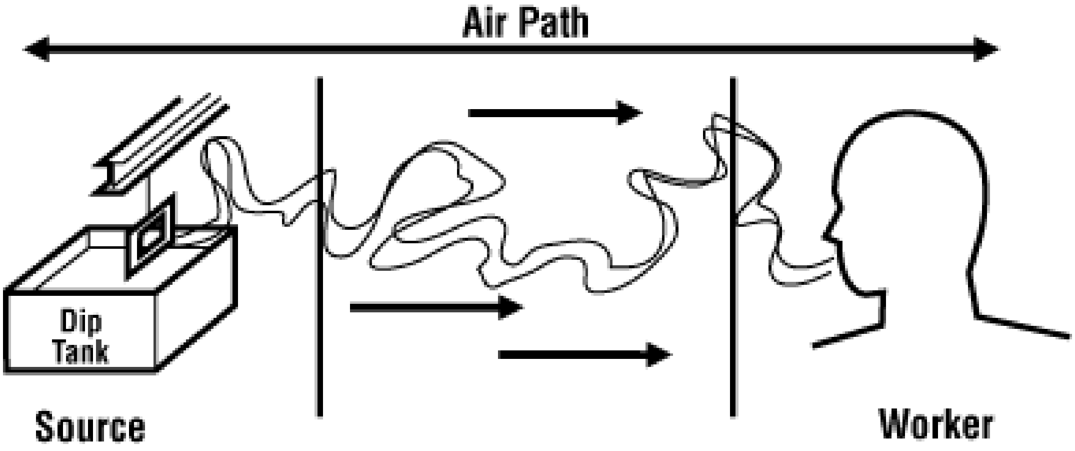


Fig. 5.4 Representation of a Industial Hazard

The table below provides some examples of hazard control

Instead Of:	**Consider:**
carbon tetrachloride (causes liver damage, cancer)	1,1,1-trichloroethane, dichloromethane
benzene (causes cancer)	toluene, cyclohexane, ketones
pesticides (causes various effects on body)	"natural" pesticides such as pyrethrins
organic solvents (causes various effects on body)	water-detergent solutions
leaded glazes, paints, pigments (causes various effects on body)	versions that do not contain lead
sandstone grinding wheels (causes severe respiratory illness due to silica)	synthetic grinding wheels such as aluminium oxide

5.7 Safety Education and Training

Education and training are important tools for informing workers and managers about workplace hazards and controls so they can work more safely and be more productive. Another role of education and training, however, is to provide workers and managers with a greater understanding of the safety and health program itself, so that they can contribute to its development and implementation.

Education and training provides employers, managers, supervisors, and workers with:

- Knowledge and skills needed to do their work safely and avoid creating hazards that could place themselves or others at risk.
- Awareness and understanding of workplace hazards and how to identify, report, and control them.
- Specialized training, when their work involves unique hazards.

Additional training may be needed depending on the roles assigned to employers or individual managers, supervisors, and workers. For example, employers, managers, and supervisors may need specific training to ensure that they can fulfill their roles in providing leadership, direction, and resources for the safety and health program. Workers assigned specific roles in the program (e.g., incident investigation team members) may need training to ensure their full participation in those functions.

Effective training and education can be provided outside a formal classroom setting. Peer-to-peer training, on-the-job training, and worksite demonstrations can be effective in conveying safety concepts, ensuring an understanding of hazards and their controls, and promoting good work practices.

Provide program awareness training

Managers, supervisors, and workers all need to understand the program's structure, plans, and procedures. Having this knowledge ensures that everyone can fully participate in developing, implementing, and improving the program.

How to accomplish it

- ✓ Provide training to all managers, supervisors, workers, and contractor, subcontractor, and temporary agency workers on:
    - ➢ Safety and health policies, goals, and procedures
    - ➢ Functions of the safety and health program
    - ➢ Whom to contact with questions or concerns about the program (including contact information)
    - ➢ How to report hazards, injuries, illnesses, and close calls/near misses
    - ➢ What to do in an emergency
    - ➢ The employer's responsibilities under the program
    - ➢ Workers' rights under the Occupational Safety and Health Act
- ✓ Provide information on the safety and health hazards of the workplace and the controls for those hazards.
- ✓ Ensure that training is provided in the language(s) and at a literacy level that all workers can understand.
- ✓ Emphasize that the program can only work when everyone is involved and feels comfortable discussing concerns; making suggestions; and reporting injuries, incidents, and hazards.
- ✓ Confirm, as part of the training, that all workers have the right to report injuries, incidents, hazards, and concerns and to fully participate in the program without fear of retaliation.

◆

2 MARK QUESTION AND ANSWERS

TWO MARKS QUESTION & ANSWERS UNIT-WISE

UNIT – 1

1. Analyse about OSHA safety and health standard

☐ **Prevent** workplace injuries and illnesses

☐ **Improve** compliance with laws and regulations

☐ **Reduce** costs, including significant reductions in workers' compensation premiums ☐ **Engage** workers

☐ **Enhance** their social responsibility goals

☐ **Increase** productivity and enhance overall business operations

2. Define Incident rate

An incidence rate (also known as an accident rate) is a way of measuring the safety of a workplace. It also helps companies determine whether the safety programs they have implemented are working. The rate is calculated based on the number of accidents that happen during a particular period of time.

3) Formulate the Four most significant events in the history of the safety and health movement

1700 – Bernardino Ramazzini, widely considered the “father of industrial medicine,” publishes his first book on occupational diseases, De Morbis Artificum Diatriba (The Diseases of Workmen).

1864 – North America’s first accident insurance policy is issued.

1867 – Phillipa Flowerday is hired by the firm of J. & J. Colman in Norwich, Great Britain. Her employment at this mustard company is considered the earliest recorded evidence of a company specifically hiring an industrial nurse.

1869 – The Pennsylvania Mine Safety Act passes into law.

1877 – The state of Massachusetts institutes the first government-sponsored factory inspection program.

1880 – The American Society of Mechanical Engineers, a professional, technical organization, responsible for developing safety codes for boilers and elevators, is founded.

1888 – Betty Moulder of Pennsylvania works with coal miners.

1895 – Vermont Marble Company initiates Industrial Nursing Service with Ada Mayo Stewart as the industrial nurse.

1896 – The National Fire Protection Association is founded to prevent fires and to write codes and standards.

1897 – Great Britain passes a workmen's compensation act for occupational injuries. English legislators would later (1906) extend the act to encompass occupational diseases.

1902 – The state of Maryland passes the first workers' compensation law.

4) Identify the three E's of safety

The 5 E's - Education, Encouragement, Enforcement, Evaluation, and Engineering.

5) State Outline the various classification of Fire

Class A: solid materials such as wood or paper, fabric, and some plastics. Class B: liquids or gas such as alcohol, ether, gasoline, or grease. Class C: electrical failure from appliances, electronic equipment, and wiring. Class D: metallic substances such as sodium, titanium, zirconium, or magnesium.

6. List the objectives of integration proposed by H. G. Dyktor

H.G. Dyktor proposed the following objectives of integration (cooperation):

- Learn more through sharing knowledge about health problems in the workplace, particularly those caused by toxic substances
- Provide a greater level of expertise in evaluating health and safety problems. Provide a broad database that can be used to compare health and safety problems experienced by different companies in the same industry.
- Encourage accident prevention
- Make employee health and safety a high priority

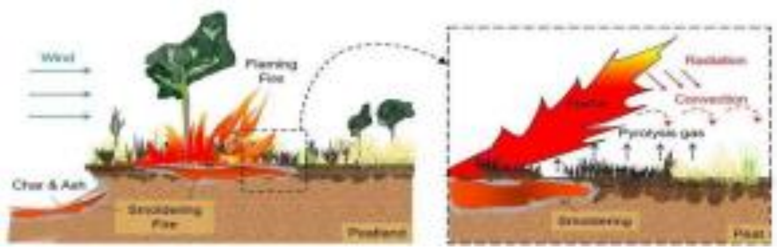
7. Identify the elements that are required to start and sustain fire

Oxygen, heat, and fuel are frequently referred to as the "fire triangle." Add in the fourth element, the chemical reaction, and you actually have a fire "tetrahedron." The important thing to remember is: take any of these four things away, and you will not have a fire or the fire will be extinguished.

8. Sketch and explain flaming mode and smoldering mode of fire

smoldering fires most often occur when smoking materials, such as cigarettes, are left unattended. These fires produce a large amount of thick smoke, which can contain toxic chemicals like carbon monoxide and cyanide.

flaming fires result from the ignition of flammable liquids, wood, paper, or open flames that ignite other items. These fires produce large quantities of flames with smaller amounts of smoke and are the most common types of home fires. A smoldering fire can also become a flaming fire, as the fire moves through the home and ignites different materials.



9. Define flash point

Flash point” is the minimum temperature at which a liquid gives off vapor within a test vessel in sufficient concentration to form an ignitable mixture with the air near the surface of the liquid. The lower the flash point, the easier it is to ignite a liquid solvent.

10) prioritize the colors and its specific category of hazard as devised by the national fire protection association (NFPA)

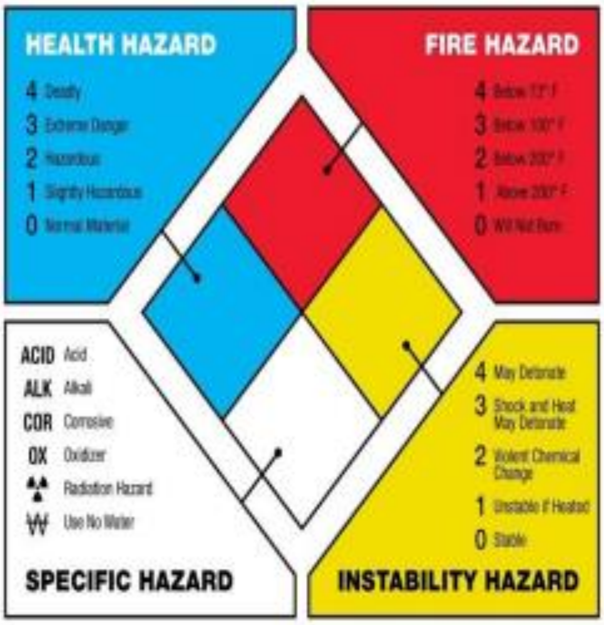
The hazards shown are • Flammability (red), • Health Hazard (blue), • Reactivity (yellow), and • Special (white). The number within each diamond represents the "level" of the hazard. Each level represents a specific degree of hazard depending on the category.

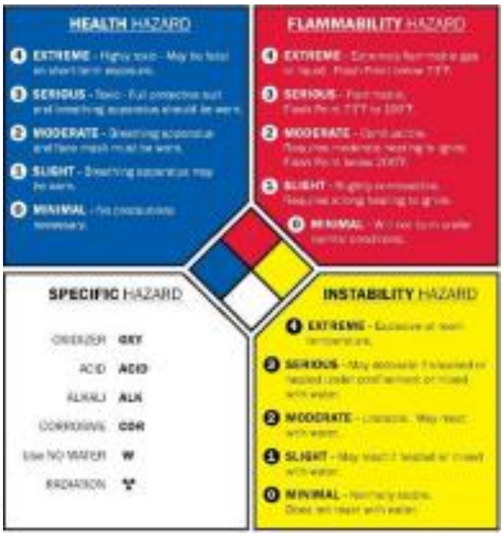
WHITE: Special Hazard / PPE

YELLOW: Reactivity Ratings

BLUE: Health Hazard Ratings

RED: Flammability Ratings





11. Examine some of the common source of mechanical hazards

Mechanical hazards arise from relative movements between parts of the human body and objects such as work equipment or work objects, which lead to their contact. The result of this contact can be accidents that lead to injuries.

12. Organize the classification of pressure vessels

Pressure vessels are divided into reaction pressure vessels, heat exchange pressure vessels, separation pressure vessels, and storage pressure vessels according to the principle of action in the production process.

13. State the Talk about pressure and pressure hazard

Pressure (P) is defined as the amount of force (F) exerted over an area (A), or P =

F/A The main hazards are:

 impact from the blast of an explosion or release of compressed liquid or
gas impact from parts of equipment that fail or any flying debris
 contact with the released liquid or gas, such as steam
 fire resulting from the escape of flammable liquids or gases

14. Evaluate the potential safety hazard associated with boilers

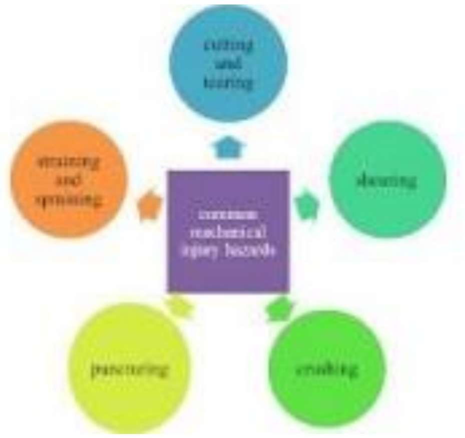
Boiler Safety

- A Risk of Explosion Exists.
- High Pressure steam.
- Combustion Gases.
- Chemicals.
- Moving Machinery.
- Hot Surfaces.

15. Categorize the common mechanical hazards

Mechanical hazards include:

- Crushing.
- Shearing.
- Cutting or severing.
- Entanglement.
- Drawing-in or trapping.
- Impact.
- Stabbing or puncture.
- Friction or abrasion.
- High-pressure fluid injection.



16. Define NIOSH

The **National Institute for Occupational Safety and Health** is the United States federal agency responsible for conducting research and making recommendations for the prevention of work related injury and illness.

17. Recall and define electricity?

electricity, phenomenon associated with stationary or moving electric charges. Electric charge is a fundamental property of matter and is borne by elementary particles. In electricity the particle involved is the electron, which carries a charge designated, by convention, as negative.

18. Illustrate ohm’s law?

Ohm’s law states that the voltage across a conductor is directly proportional to the current flowing through it, provided all physical conditions and temperatures remain constant. Mathematically, this current-voltage relationship is written as, Ohm's Law Equation. In the equation, the constant of proportionality, R, is called Resistance and has units of ohms, with the symbol Ω.

The same formula can be rewritten in order to calculate the current and resistance respectively as follows:

Ohm's Law Equation

$$V=IR \quad I = \frac{V}{R} \quad R = \frac{V}{I}$$

19. Classify the classes of hazardous locations for electrical equipment

Class I: Gases or vapors. Class I hazardous areas may contain flammable vapors or gases in quantities large enough to cause a fire or an explosion. Examples of these gases and vapors include hydrogen, carbon monoxide, and ethylene oxide.

Class II: Dust.Class II hazardous areas may contain combustible or conductive dust in quantities large enough to cause a fire or an explosion. Examples of these dusts include metal dusts such as aluminum dust or carbon-based dusts such as coal dust.

Class III: Fibers and flying. Class III hazardous areas may contain fibers and flyings (i.e., small airborne parts) in quantities large enough to ignite and cause a fire or an explosion. Examples of these fibers and flyings include wood, plastic, and grain.

20. Summarize about let – go current

9 to 30 Milliamps (men) The freezing current or “let go” range. If extensor muscles are excited by shock, the person may be thrown away from the power source. Individuals cannot let go. Strong involuntary reactions can lead to other injuries.

UNIT - 2

1) What causes chemical burn injuries?

Chemical burns are tissue damage caused by strong acids, drain cleaners, paint thinner, gasoline and many other substances. Usually, you are aware of such a burn and its cause.

2) Recommend any two strategies to prevent chemical burn injuries

Advice for preventing chemical burns

Make sure all chemicals and harmful substances are stored correctly and in a safe place. Chemicals should be kept in their original containers, and labelled correctly.

Regular staff training should be carried out to ensure workers know how to handle chemicals correctly.

3. List down some chemicals that most frequently cause chemical burn injuries

Common causes of chemical burns include the following: Acids: Sulfuric, nitric, hydrofluoric, hydrochloric, acetic acid, formic, phosphoric, phenols, and chloroacetic acid.

4. Organize the hazardous effects of chemical burns

Serious chemical burns can cause long-term complications: Many people have pain and scarring. Burns in the eye can lead to blindness. Swallowing harmful chemicals can lead to problems in your gastrointestinal tract, potentially leading to permanent disability.

5. Identify the factors that are the reasons for toxic effects

- Biological Variation.
- Rate Of Removal.
- Dosage and
- Toxicity Point Of Entry.

6. Define Toxic Substance.

A toxicant is any toxic substance. Toxicants can be poisonous and they may be man-made or naturally occurring. By contrast, a toxin is a poison produced naturally by an organism. The different types of toxicants can be found in the air, soil, water, or food.

7. Classify airborne toxic substances based on its type of effects on human body

Air toxics include heavy metals like mercury, as well as persistent organic pollutants (POPs) like pesticides and DDT. These airborne contaminants are especially harmful, because they are long lasting and do not break down in the environment, can build up in tissues of organisms, and have toxic effects.

8. Recall about respirable silica exposure

Silicosis, an irreversible but preventable lung disease, is caused by inhalation of respirable silica dust. Work exposures to silica dust also cause other serious diseases, including lung cancer.

9. Criticize the factors that govern the severity of burns produced by a given chemical

- Source of the Burn.
- Degree of Burn.
- Percentage of the Body Burned (Body Regions Burned).
- Location of the Burn.
- Complications Accompanying the Burn.
- Age of the Patient.

10. Inspect and list out the common routes of entry for toxic agents

There are four major routes by which a chemical may enter the body:

- Inhalation (breathing)
- Skin (or eye) contact.
- Swallowing (ingestion or eating)
- Injection.

11. Define toxicology and toxic effects

Toxic effect is an adverse change in the structure or function of an experimental animal as a result of exposure to a chemical substance.

Toxicology is the study of the adverse effects of chemicals or physical agents on living organisms. A toxicologist is a scientist that determines the harmful effects of agents and the cellular, biochemical, and molecular mechanisms responsible for the effects.

12. Relate and explain the terms ionize and ionizing radiation

A type of high-energy radiation that has enough energy to remove an electron (negative particle) from an atom or molecule, causing it to become ionized. Ionizing radiation can cause chemical changes in cells and damage DNA.

Ionizing radiation is a form of energy that acts by removing electrons from atoms and molecules of materials that include air, water, and living tissue. Ionizing radiation can travel unseen and pass through these materials.

13. Demonstrate industrial hygiene

Anticipate: Sense the presence or potential of hazards without actually observing them

- Recognize: Identify a hazard when it's observed
- Evaluate: Determine what type of harm a hazard can cause and how severe the harm would be
- Communicate: Inform others in the workplace or community about the hazard
- Control: Put measures into place to eliminate or minimize the potential of the hazard to create harm, such as injury or illness.

14. Illustrate the types of ionizing radiation

There are seven natural forms of EMR. Gamma rays have the highest energy and shortest wavelength. Then come X-rays, ultraviolet light, visible light, infrared radiation and microwave radiation. Finally, radio waves have the lowest energy and longest wavelength.

15. Develop any two requirements related to industrial hygiene as per OSH Act

OSHA requirements relating to industrial hygiene

- ➢ Use of warning labels and other means to make employees aware of potential hazards, symptoms of exposure, precautions, and emergency treatment
- ➢ Prescription of appropriate personal protective equipment and other technological preventive measures
- ➢ Provision of medical tests to determine the effect on employees of exposure to environmental stressors
- ➢ Maintenance of accurate records of employee exposures to environmental stressors that are required to be measured or monitored
- ➢ Accessibility of monitoring tests and measurement activities to employees
- ➢ Availability of monitoring tests and measurement activity records to employees on request
- ➢ Notification of employees who have been exposed to environmental stressors at a level beyond the recommended threshold and corrective action being taken.

16. Elaborate about Non-ionizing radiation

A type of low-energy radiation that does not have enough energy to remove an electron (negative particle) from an atom or molecule. Non-ionizing radiation includes visible, infrared, and ultraviolet light; microwaves; radio waves; and radiofrequency energy from cell phones.

17. Outline the three acceptable ways to dispose Radioactive wastes

Deep geological disposal is widely agreed to be the best solution for final disposal of the most radioactive waste produced.

- ☐ Space Disposal.
- ☐ Transmutation.
- ☐ Reprocessing.
- ☐ Geological Disposal.

18. Examine the concerns of industrial hygienists?

Industrial hygienists analyse, identify, and measure workplace hazards or stresses that can cause sickness, impaired health, or significant discomfort in workers through chemical, physical, ergonomic, or biological exposures.

19. Examine the concept “ ALARA”

ALARA stands for “as low as reasonably achievable”. ALARA means avoiding exposure to radiation that does not have a direct benefit to you, even if the dose is small. To do this, you can use three basic protective measures in radiation safety: time, distance, and shielding.

20. Identify the two principal types of industrial poisoning

1. Carbon Tetrachloride
2. Methylene Chloride
3. 1-Bromopropane
4. Pigment Violet 29

UNIT -3

1. List out the forms of atmospheric contaminants

- Air Pollutants
- Carbon Monoxide.
- Lead.
- Nitrogen Oxides.
- Ozone.
- Particulate Matter.
- Sulphur Dioxide.
- Other Air Pollutants.

2. Explain the term PPE

Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses.

3. What is hazardous noise?

Noise above 70 dB over a prolonged period of time may start to damage your hearing. Loud noise above 120 dB can cause immediate harm to your ears.

4. Identify the frequencies of infrasound and ultrasound

Ultrasound, which includes biologically significant sounds ranging from 15 kHz or so up to 200 kHz, is too high in frequency. Infrasound, effectively extending downwards from about 20 to 0.1 Hz or less, is too low in frequency.

5. Develop the factors by which motion be characterized

You can describe the motion of an object by its position, speed, direction, and acceleration. An object is moving if its position relative to a fixed point is changing.

6. Define threshold of hearing and threshold of pain

The hearing threshold is the sound level below which a person's ear is unable to detect any sound. For adults, 0 dB is the reference level. A threshold shift is an increase in the hearing threshold for a particular sound frequency.

Pain threshold is the minimum intensity at which a person begins to perceive, or sense, a stimulus as being painful. Pain tolerance, is the maximum amount, or level, of pain a person can tolerate or bear.

7. Classify the conditions for health hazards in industry

Health risks at the workplace, such as heat, noise, dust, hazardous chemicals, unsafe machines and psychological stress, cause occupational diseases and can aggravate other health problems. Conditions of employment, occupation and the position in the workplace hierarchy also affect health.

8. List out some strategies to prevent vibration related injuries

Using anti-vibration gloves designed with state-of-the-art materials. Implementing regularly scheduled breaks to avoid constant exposure. Performing regular maintenance on machinery to prevent excessive vibration. Screening workers regularly through a specialized hand-arm vibration medical exam.

Provide your employees with protective clothing when necessary to keep them warm and dry. This will encourage good blood circulation which should help protect them from developing vibration white finger. Gloves can be used to keep hands warm, but should not be relied upon to provide protection from vibration.

9. Elaborate Impulsive noise

Impulse noise is a category of (acoustic) noise that includes unwanted, almost instantaneous (thus impulse-like) sharp sounds (like clicks and pops)—typically caused by electromagnetic interference, scratches on disks, gunfire, explosions, and synchronization issues in digital audio.

10. Discover some approaches to prevent the inhalation of hazardously contaminated air

□ Dust containment carts at small openings in ceilings and walls for maintenance. □ Anterooms to seal off entrances to rooms in which dust is being generated. □ Barrier wall systems to seal off large areas under construction.

11. Recall about vibration

Vibration is the mechanical oscillations of an object about an equilibrium point. The oscillations may be regular such as the motion of a pendulum or random such as the movement of a tire on a gravel road.

12. Tell about Dosimeter

A radiation dosimeter or badge does not provide protection but detects and measures radiation that you have been exposed to. The badge will detect high-energy beta, gamma or x-ray radiation.

There are two general types: dosimeter badges, which are used to measure cumulative doses over periods of weeks or months, and pocket dosimeters, which are generally used for monitoring over a shorter term.

13. Illustrate the basic requirements generated by OSHA standards for hearing conservation program

Audiometric testing monitors an employee's hearing over time.

The hearing conservation program requires employers to monitor noise exposure levels in a way that accurately identifies employees exposed to noise at or above 85 decibels (dB) averaged over 8 working hours, or an 8-hour time-weighted average (TWA).

14. Compare whole body vibration and segmental vibration.

Whole body vibration is a generic term used when vibrations of any frequency are transferred to the human body. Humans are exposed to vibration through a contact surface that is in a mechanical vibrating state. Humans are generally exposed to many different forms of vibration in their daily lives.

Segmental vibration exposure affects an organ, part or "segment" of the body. The most widely studied and most common type of segmental vibration exposure is hand-arm vibration exposure which affects the hands and arms.

15. Determine the critical noise risk factors

Repeated exposures to loud noise can lead to permanent tinnitus and/or hearing loss. Loud noise can create physical and psychological stress, reduce productivity, interfere with communication and concentration, and contribute to workplace accidents and injuries by making it difficult to hear warning signals.

16. Propose the steps to be followed to identify and assess hazardous noise in workplace

 Intensity/Loudness: This factor is measured by a noise level meter and the units are described in decibels (dB)

 Frequency: Frequencies between 3000-4000 Hz are most likely to damage human hearing. Sound level meters account for this by using an “A” weighted filter Duration: The length of time you have been exposed to noise

17. Classify some personal hearing protection devices.

Earmuffs, earplugs, electronic hearing protection devices, and semi-insert devices.

18. Compare sound and noise

Sound is what we hear. Noise is unwanted sound. The difference between sound and noise depends upon the listener and the circumstances. Rock music can be pleasurable sound to one person and an annoying noise to another.

19. Classify the three broad types of industrial noise

Types of industrial noise: -

- Wide band noise: is noise that is distributed over a wide range of frequencies. Most noise from manufacturing machines is wide band noise.
- Narrow band noise: is noise that is confined to a narrow range of frequencies. The noise produced by power tools is narrow band noise.
- Impulse noise: consists of transient pulses that can occur repetitively or non repetitively. The noise produced by a jackhammer is repetitive impulse noise.

20. Identify some fields where personal protection is needed with reason

1. SAFETY FOR THE HEAD

Wearing a helmet offers protection and can prevent head injuries. Select a sturdy helmet that is adapted to the working conditions. These days you can find many elegant designs and you can choose extra options such as an adjustable interior harness and comfortable sweatbands.

2. PROTECT YOUR EYES

The eyes are the most complex and fragile parts of our body. Each day, more than 600 people worldwide sustain eye injuries during their work. Thanks to a good pair of safety glasses, these injuries could be prevented. Do you come into contact with bright light or infrared radiation? Then welding goggles or a shield offer the ideal protection.

3. HEARING PROTECTION

Earplugs are very comfortable, but earmuffs are convenient on the work floor as you can quickly put these on or take them off.

4. MAINTAIN A GOOD RESPIRATION

Wearing a mask at work is no luxury, definitely not when coming into contact with hazardous materials. 15% of the employees within the EU inhale vapours, smoke, powder or dusk while performing their job. Dust masks offer protection against fine dust and other dangerous particles. If the materials are truly toxic, use a full-face mask. This adheres tightly to the face, to protect the nose and mouth against harmful pollution.

5. PROTECT YOUR HANDS WITH THE RIGHT GLOVES

Hands and fingers are often injured, so it is vital to protect them properly. Depending on the sector you work in, you can choose from gloves for different applications:

6. PROTECTION AGAINST VIBRATIONS

protection against cuts by sharp materials protection against cold or heat protection against bacteriological risks protection against splashes from diluted chemicals.

7. PROTECTION FOR THE FEET

Feet protection

Even your feet need solid protection. Safety shoes and boots are the idea An antiskid sole is useful when working in a damp environment, definitely if you know that 16,2% of all industrial accidents are caused by tripping or sliding. On slippery surfaces, such as snow and ice, shoe claws are recommended. Special socks can provide extra comfort.

8. WEAR THE CORRECT WORK CLOTHING

Work clothing

Preventing accidents is crucial in a crowded workshop. That is why a good visibility at work is a must: a high-visibility jacket and pants made of a strong fabric can help prevent accidents. Just like the hand protection, there are versions for different applications.

UNIT - 4

1. What is meant by system safety analysis?

System safety analysis (SSA) is a field within safety engineering that uses a proactive approach to risk management. SSA looks ahead to system failure and anticipated human behavior and interaction with system process equipment.

2. List the requirement of system safety analysis

As critical aspect of any system safety program entails the identification of hazards, assessment of the risk associated with the identified hazards, the determination of effective mitigations to control the risks to acceptable levels, and verifying and validating the implementation of those mitigations.

3. How may systems be used to reduce hazards?

There are five general categories of control measures: elimination, substitution, engineering controls, administrative controls and personal protective equipment.

4. What is required for effective system safety analysis?

As critical aspect of any system safety program entails the identification of hazards, assessment of the risk associated with the identified hazards, the determination of effective mitigations to control the risks to acceptable levels, and verifying and validating the implementation of those mitigations.

5. Describe fault tree analysis.

Fault tree analysis is a type of failure analysis in which an undesired state of a system is examined. Fault tree analysis (FTA) is an investigation of how a selected “top” fault (abnormal condition) or failure event, for example, an unintended/undesired release of a hazardous material, can be resolved into its causes.

6. Give the advantages of fault tree analysis.

- improve compliance with safety regulations.
- map the correlation between failures and subsystems.
- establish priorities for the system as a whole. Implement changes in product or system design to minimize risks.
- carry out a probabilistic risk assessment (PRA).

7. Discuss the Risk associated with Industrial work.

1. Physical
    - Noise, Radiation,
    - Temperature, Extremes
2. Chemical
3. Ergonomic
4. Biological

8. Name several of the prominent system analysis techniques.

- Grid Charts.
- Simulation.
- System Flow Chart.
- Decision Tree.
- Decision Tables.

9. What is the role of the Hazard Analysis?

The goal of hazard analysis is to find ways to minimize the chance of injury, loss or harm while you are working on your project.

10. Analyse the basic elements of a Hazard Analysis

- Review the hazardous processes that take place in a facility.
- Identify the steps in those processes that cause abnormal or unsafe results. Create records to represent the various scenarios for each process. These scenarios are the components of the analysis.

11. What is the Relationship between Safety and Reliability?

- Reliability requirements are concerned with making a system failure-free. Definition: Safety is the probability, that no catastrophic accidents will occur during system operation, over a specified period of time. Safety looks at the consequences and possible accidents.
- Safety is achieved through the use of reliable structures, components, systems and procedures. Reliability is the probability that a system or component will perform its intended function for a prescribed time and under stipulated environmental conditions.

12. What General Procedures Should Follow in the Performance of a Hazard Analysis?

- Step 1: Identify known hazards.
- Step 2: Implement quick fixes.
- Step 3: Prioritize job hazards.
- Step 4: Break down jobs into tasks.
- Step 5: Identify hazards of each task.
- Step 6: Identify control and prevention measures.

13. List the use of HAZOP from multiple perspectives.

The HAZOP approach is commonly used with chemical production and piping systems, where miles of pipes and numerous containers can result in logistical headaches. It is best suited for assessing hazards in facilities, equipment, and processes and can assess systems from multiple perspectives.

HAZOP is used as part of a Quantitative Risk Assessment (QRA) or as a standalone analysis. HAZOP is a more detailed review technique than HAZID. The purpose of the HAZOP is to investigate how the system or plant deviate from the design intent and create risk for personnel and equipment and operability problems.

14. What is meant by HAZOP analysis?

The purpose of the HAZOP is to investigate how the system or plant deviate from the design intent and create risk for personnel and equipment and operability problems.

15. Define the term Risk

1. Possibility of loss or injury : peril. 2 : someone or something that creates or suggests a hazard. 3. The chance of loss or the perils to the subject matter of an insurance contract also. The degree of probability of such loss.

16. Propose the Safety Order of Precedence?

- Elimination – Physically remove the hazard
- Substitution – Replace the hazard
- Engineering controls – Isolate people from the hazard
- Administrative controls – Change the way people work
- Personal protective equipment– Protect the worker with PPE

17. Brief the term FMEA?

Failure Modes and Effects Analysis (FMEA) is a systematic, proactive method for evaluating a process to identify where and how it might fail and to assess the relative impact of different failures, in order to identify the parts of the process that are most in need of change.

18. Compile the drawbacks of FTA?

The disadvantages are twofold. If FTAs are not set up within the right framework of policies, they can diminish rather than enhance economic welfare. The second disadvantage is that they are not good vehicles for liberalising trade in sectors on which parties outside the agreement have a major influence.

19. List the series of questions that are answered by Fault Hazard Analysis?

This analysis method is mainly used in safety engineering and reliability engineering to understand how systems can fail, to identify the best ways to reduce risk and to determine (or get a feeling for) event rates of a safety accident or a particular system level (functional) failure.

FTA is a systematic and deductive method for defining a single undesirable event and determining all possible reasons that could cause that event to occur. The undesired event constitutes the top event of a fault tree diagram, and generally represents a complete or catastrophic failure of a product or process.

20. What are the objectives of HAZOP?

- For identifying cause and the consequences of perceived mal-operations of equipment and associated operator interfaces in the context of the complete system.
- It accommodates the status of recognized design standards and codes of practice but rightly questions the relevance of these in specific circumstances where hazards may remain undetected.
- To check adequacy of existing safeguards and propose new safeguards to reduce risk.

UNIT -5

1. Enlist the points to be considered for safety in industries as per The Factories Act, 1948

- Section 21: Fencing the Machinery
- Section 22: Work on or Near Machinery in Motion
- Section 23: Employment on Dangerous Machines
- Section 24: Devices for Cutting off Power
- Section 25: Self-Acting Machinery
- Section 26: Casing of New Machinery
- Section 27: Prohibition of Employment of Women and Children Near Cotton-Openers

2. Elaborate the term catastrophe control

A catastrophe is an event that results in extensive damage or destruction. Catastrophe control is a set of procedures and protocols that are put in place to minimize the damage caused by a catastrophe. These procedures and protocols typically include things like evacuations, emergency response plans, and disaster recovery plans.

3. List major industrial accident in India

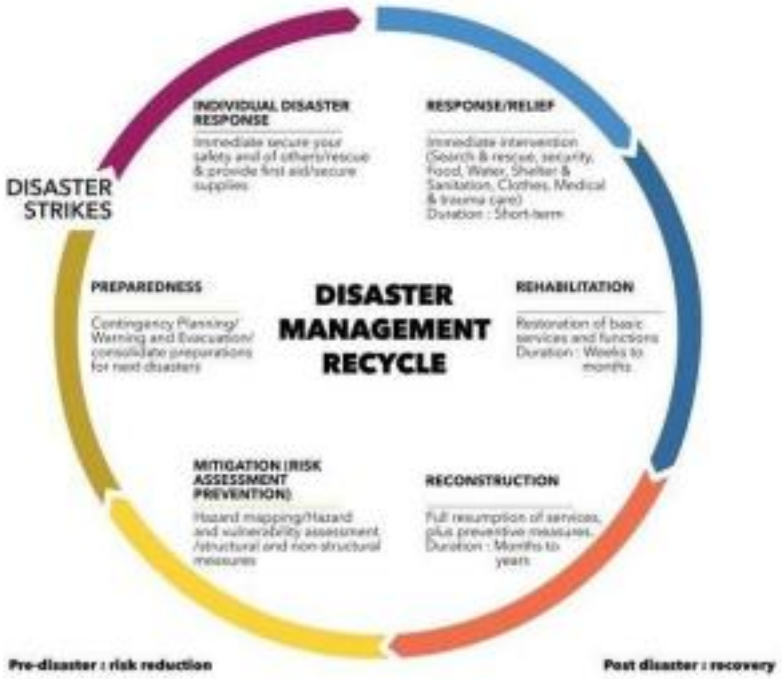
- Bhilai Steel Plant Pipeline Blast (2018).
- Belur Chlorine Gas Leak (2017).
- Kanpur Ammonia Gas Leak (2017).
- Tughlakabad Gas Leak (2017).
- Bhilai Steel Plant Gas Leak (2014).
- Nagaram GAIL pipeline explosion (2014).
- Visakhapatnam HPCL Refinery Blast (2013).
- Mayapuri Radiolgical Accident (2010).
- Jaipur Oil Depot Fire (2009).
- Korba Chimney Collapse (2009).
- The Union Carbide Gas Tragedy (1984).
- Chasnala Mining Disaster (1975).
- Bombay Docks Explosion (1944).

4. Develop the general factors of disaster

- Climate change.
- Enviromental degradation.

- Globalized economic development.
- Poverty and inequality.
- Poorly planned urban development.
- Weak governance.

5. Draw the basic format of the disaster management cycle.


DISASTER STRIKES
INDIVIDUAL DISASTER RESPONSE
Immediate secure your safety and of others/rescue & provide first aid/secure supplies
RESPONSE/RELIEF
Immediate intervention (Search & rescue, security, Food, Water, Shelter & Sanitation, Clothes, Medical & trauma care)
Duration : Short-term
PREPAREDNESS
Contingency Planning/ Warning and Evacuation/ consolidate preparations for next disasters
DISASTER MANAGEMENT RECYCLE
REHABILITATION
Restoration of basic services and functions
Duration : Weeks to months
MITIGATION (RISK ASSESSMENT PREVENTION)
Hazard mapping/Hazard and vulnerability assessment /structural and non-structural measures
RECONSTRUCTION
Full resumption of services, plus preventive measures.
Duration : Months to years
Pre-disaster : risk reduction
Post disaster : recovery

6. What are the factors that are the bases for an explosion?

In general, an explosive has four basic characteristics: (1) It is a chemical compound or mixture ignited by heat, shock, impact, friction, or a combination of these conditions; (2) Upon ignition, it decom- poses rapidly in a detonation; (3) There is a rapid release of heat and large quantities of high-pressure gases.

7. Illustrate are the common sources of highly polluting waste from industry

A great deal of industrial pollution comes from manufacturing products from raw materials—(1) iron and steel from ore, (2) lumber from trees, (3) gasoline and other fuels from crude oil, and (4) stone from quarries.

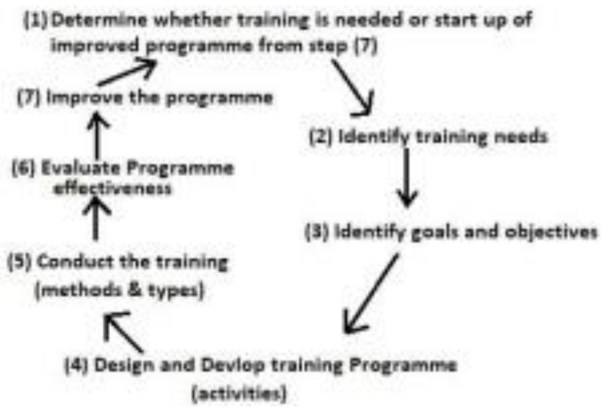
8. Define the term Disaster

Disasters are serious disruptions to the functioning of a community that exceed its capacity to cope using its own resources. Disasters can be caused by natural, man-made and technological hazards, as well as various factors that influence the exposure and vulnerability of a community.

9. Generalize some Special provisions given by Factories Act, 1948.

In every factory (a) adequate and suitable facilities shall be provided and maintained for the use of workers; (b) separate and adequately screened facilities shall be provided for the use of male and female workers; (c) such facilities shall be easily accessible and shall be kept clean.For protecting the health of workers, the Act lays down that every factory shall be kept clean and all necessary precautions shall be taken in this regard. The factories should have proper drainage system, adequate lighting, ventilation, temperature etc. Adequate arrangements for drinking water should be made.

10. Classify the approaches to determine the safety training needs


(1) Determine whether training is needed or start up of improved programme from step (7)
(2) Identify training needs
(3) Identify goals and objectives
(4) Design and Devlop training Programme (activities)
(5) Conduct the training (methods & types)
(6) Evaluate Programme effectiveness
(7) Improve the programme

Determine safety training needs and p by four approaches stated in above. Design training to meet the needs. The St (a) Assess training requirements (b) Determine training contents (c) Decide training Methods and aids (d) Organize training contents (e) Formulate training plan and (f) evaluations measures.

11. What are the forms of flammable material?

Flammable materials come in many forms, including liquids, gases, solids, and dusts.

12. Define the term vulnerability

Vulnerability is the inability to resist a hazard or to respond when a disaster has occurred. For instance, people who live on plains are more vulnerable to floods than people who live higher up.

13. State risk

Risk is the chance or probability that a person will be harmed or experienced an adverse health effect if exposed to a hazard. It may also apply to situation with property or equivalent loss or harmful effects on environment.

14. Explain about "Powers of Inspectors" as per The Factories Act, 1948

To photograph any worker, to inspect, examine, measure, copy, photograph sketch or test, as the case may be, any building or room, any plant, machinery, appliance or apparatus, any register or document or anything provided for the purpose of securing the health, safety or welfare of the workers employed in a factory.

15. Summarize about Artificial humidification as per The Factories Act, 1948

In any factory in which the humidity of the air is artificially increased, the water used for the purpose shall be taken from a public supply, or other source of drinking water, or shall be effectively purified before it is so used.

16. Enlist the chapters in Factory act 1948

- CHAPTER - I PreliminaryCHAPTER - II The Inspecting Staff.
- CHAPTER - III Health.
- CHAPTER - IV Safety.
- CHAPTER - IVA Provisions relating to Hazardous processes.
- CHAPTER - V Welfare.
- CHAPTER - VI Working hours of adults.
- CHAPTER - VII Employment of young persons.
- CHAPTER - VIII Annual leave with wages.
- CHAPTER IX Special Provisions.
- CHAPTER - X Penalties and procedure.
- CHAPTER - XI Supplemental.

17. Summarize the benefits of safety induction program.

- It provides an introduction to the working environment and the set-up of the employee within the industry.
- Good induction programmes can increase productivity and reduce short-term turnover of staff. organization.

- The process will cover the employer and employee rights and the terms and conditions of employment
  - pay attention to the health and safety of the new employee.

18. Analyse the important legislation was enacted for affecting waste disposal

Waste laws are generally designed to minimize or eliminate the uncontrolled dispersal of waste materials into the environment in a manner that may cause ecological or biological harm, and include laws designed to reduce the generation of waste and promote or mandate waste recycling. Resource Conservation and Recovery Act (RCRA) RCRA requires generators to characterize their wastes, properly manage their wastes on site, and then to manifest all wastes sent off-site for disposal.

19. Discover the aspects and goals of training methods

The aspects and goals of training methods can vary depending on the type of training being conducted. For example, if the goal of the training is to improve employee productivity, the aspects and goals of the training may focus on teaching employees new skills or improving their proficiency in existing skills. If the goal of the training is to reduce workplace accidents, the aspects and goals of the training may focus on safety procedures and hazard recognition.

20. Give the benefits of value measurement of safety training programme

- Educate employees on the basics of health and safety.
- Increased focus by employees on their tasks.
- Increased job pleasure and confidence among employees.
- Increased employee inspiration.
- Increased effectiveness in processes, deriving in financial gain.

◆

BIBLIOGRAPHY

BIBLIOGRAPHY

1. John V.Grimaldi, “Safety Management”, AITB S Publishers, 2003.

2. Safety Manual, “EDEL Engineering Consultancy”, 2000.

3. David L.Goetsch, “Occupational Safety and Health for Technologists”, 5th Edition, Engineers and Managers, Pearson Education Ltd., 2005.

4. American Petroleum Institute. Model environmental, health and safety (EHS) management system. API Publication. Report No.: 9100A. Banker. Report No.: 9100A. 1998 p.

5. Bomel (2001). Improving Health and Safety in Construction, Phase 1: Data Collection, Review and Structuring. HSE Books: Sudbury.

6. Bureau of Labour Statistics (2005). Census of Fatal Occupational Injuries 1990–2005. Department of Labour, Washington D.C.

7. Bureau of Labour Statistics (2009b). Census of Fatal Occupational Injuries 1992–2007. Department of Labour, Washington D.C.

8. British Standard Institution (2013). Occupational Health and Safety Management, Implementation Guide, British Standards Institution:London, UK.

9. DOSH (2008). Guidelines for Hazard Identification, Risk Assessment, & Risk Control.

10. Fellows, R. & Liu, A. (2003). Research methods for construction. 2nd ed. Oxford: Blackwell publishing.

11. Health and Safety Executive (HSE), (1991). Successful health and safety management. London (UK).

12. The ILO Report (2008). XVIII World Congress on Safety and Health at Work, Seoul, Korea.

தெய்வத்தான் ஆகா தெனினும் முயற்சிதன்
மெய்வருத்தக் கூலி தரும்.
வாழ விரும்புவோர்க்கு வள்ளுவனின் வாக்கு

நான் நூறு முறை ஜெயித்தவனில்லை,

ஆயிரம் முறை தோற்றவன் - **தாமஸ் ஆல்வா எடிசன்**